DETERMINING TIMBER CONVERSION ALTERNATIVES THROUGH COMPUTER ANALYSIS

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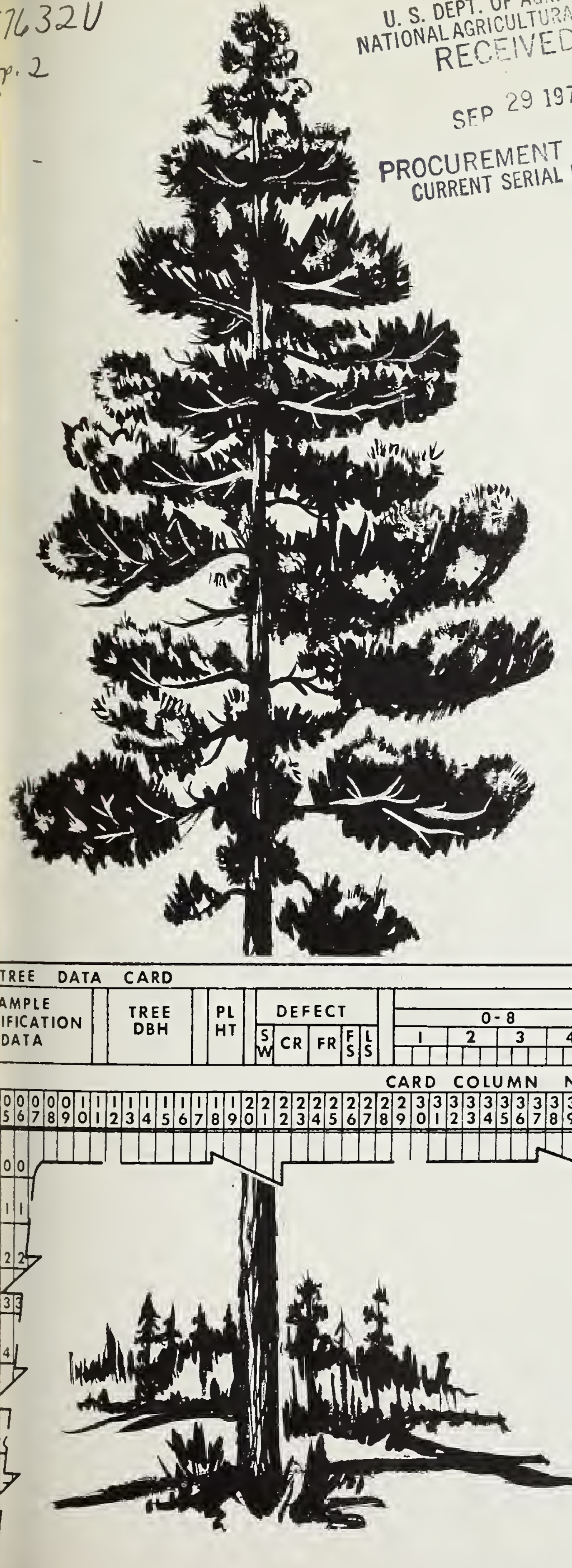

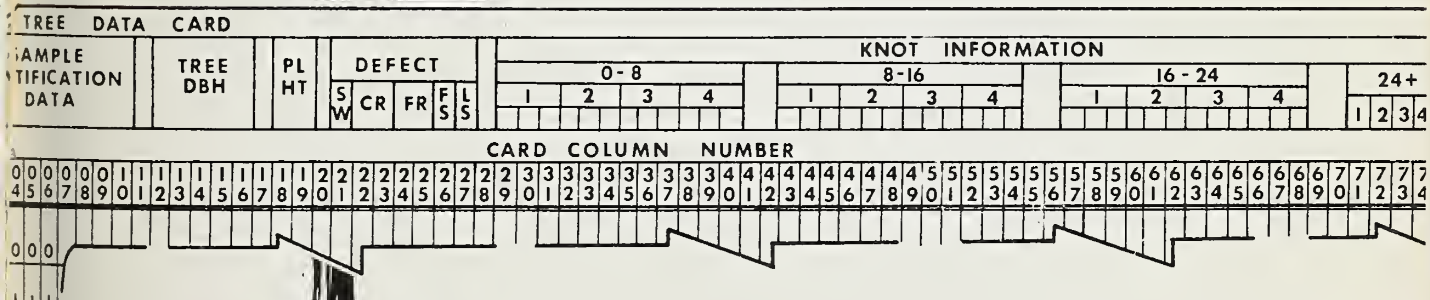

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ABSTRACT

The computer program MULTI accepts basic field inventory data describing individual sample trees. It calculates gross board-foot and cubic-foot volume, grades or classifies for a number of specified primary products, adjusts gross volume for visual defect, and calculates standard error. Output tables indicate adjusted gross volume per acre, by grade and size class, for each product independently. An option allows allocation of volume between several products of a multiproduct combination following a specified order of preference.

MULTI was developed on a CDC 6400 computer system. It is written in FORTRAN Extended Language, and can use tape and/or disk storage. Although the program was developed for products and grading systems common to ponderosa pine (Pinus ponderosa Laws.), it is adaptable to other species, products, and grading systems.

Key Words: Multiproduct timber inventory, primary product evaluation (timber), forest surveys, product volume estimates, product volume adjustments, timber utilization.

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Determining Timber Conversion Alternatives Through Computer Analysis

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Timber Product Evaluation

To achieve the best physical and economic utilization of his timber resource, the manager of a diversified timber operation must be able to evaluate the potential of standing timber for a variety of primary products. He must also be able to estimate the effects of one utilization program upon resource availability or suitability for any other program or product mix. In the long run, the processor can try to establish the utilization program that makes best use of the available raw material. In the short run, however, he must generally choose between existing products and markets.

A method of evaluating standing timber for a variety of primary products has been described by Barger and Ffolliott (1970). Their system may be used with any valid sampling scheme, and involves observing and recording for each sample tree the basic physical characteristics that are quality criteria for most primary timber products. Occurrence and severity of defects form the basis for estimating the potential of the timber stand to produce a variety of products.

Equally as important as the inventory information itself is the ability of the manager to evaluate these inventory data for the entire array of potential timber products. Large volumes of data must be analyzed to determine suitability for individual products and combinations of products in the array of possible conversion alternatives (fig. 1). To make practical use of inventory data, the timber manager or processor must turn to automatic data processing and computer analysis. The computer program MULTI has been written as a guideline to show one possible way to implement such a system.

MULTI—A Program to Analyze Product Potential

MULTI was developed on a CDC 6400 computer system. It is written in FORTRAN Extended Language, and can use tape and/or disk storage.

The program accepts basic field inventory data describing individual trees. It then calculates gross volume, grades or classifies for a number of primary products, adjusts volume for visual defect, and calculates standard error.

Gross volume in cubic feet or board feet, or both, may be calculated for each half-log or 8-foot stem section, to minimum merchantable saw log diameter. Board-foot volume may also be determined for 16-foot saw logs. In addition, cubic volume may be calculated for the stem section from minimum saw log top to a 4.0-inch top diameter inside bark (d.i.b.).

Depending upon the needs of the user, the program can be used to grade or classify trees or sections of trees for all possible products, or for the individual products of greatest value in a specified order of preference.

Program Adaptability

A key objective in writing the computer program MULTI was to develop a system that could easily be changed to fit individual needs. Although the program was developed for products and grading systems common to ponderosa pine (Pinus ponderosa Laws.), it is adaptable to other species, products, and grading systems.

Input parameters needed to calculate tree and log volumes and estimate product volumes

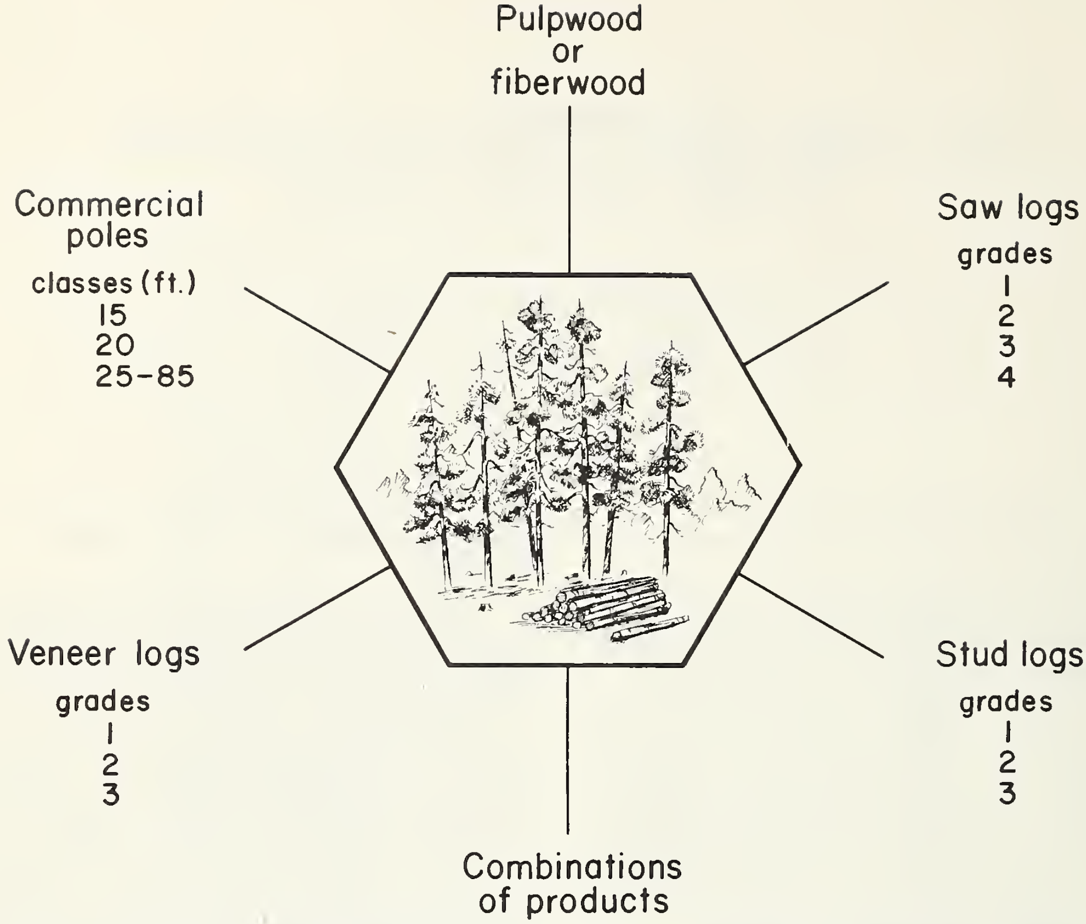


Figure 1.--There are many primary product and product-combination conversion alternatives for any particular stand of timber. Illustrated are the primary timber products considered in program MULTI.

per acre are contained on program data cards and control cards. Individual products are evaluated and graded through a series of product evaluation subroutines. Different species or products can be accommodated by substituting appropriate input parameters and product evaluation subroutines. Changes in grading systems require only that the grading section of the affected subroutine be changed.

For The Non-Programer—
A Program Description

The following information will describe for the non-programer what data are used and what is accomplished by the program.

Field Data Input

Field data recorded for each sample tree include:

1. Descriptive and size data, including
   a. Species.
   b. Diameter breast high (d.b.h.).
   c. Total tree height in merchantable half logs.
   d. Pole height for potential commercial poles.
2. Visual defect characteristics, including
   a. Stem form defects—sweep, crook, fork, lean.
   b. Stem scar defects—basal, lightning.
   c. Knot or limbing characteristics in the first 32 feet.

How these data are measured and recorded is described in detail in appendix A.

Product, Grade, and Priority Specification

The program can accommodate the full range of primary products and product grades appropriate for a particular timber type or species. The program illustrated includes and is limited to five primary products from ponderosa pine: saw logs, stud logs, veneer logs,

commercial poles, and pulpwood. Within these products, the program will accommodate four saw-log grades, three stud-log grades, three veneer-log grades (plus an "unacceptable" category in veneer and stud logs), and 15 pole height classes.

Product priorities can be specified by means of a program control card. If each tree or section is to be graded and classified for as many products as it is suitable for, no priority selection is used. The output will reflect the **total** potential of the stand for **each** product as if the entire stand were being utilized for that product. More often, however, a descending order of product priority will be specified. A typical order might be (a) commercial poles; (b) saw logs grade 1, 2, 3; (c) veneer logs grade 1, 2, 3; (d) stud logs grade 1, 2, 3; (e) saw log grade 5; (f) pulpwood. In the program illustrated, pulpwood always assumes lowest priority. Each tree or section would then be graded for these products in order of preference stated, and placed only in the highest product class for which it qualifies. If desired, a series of different product priorities can be specified, to be considered one after another.

Volume Determination

Gross cubic-foot and board-foot volume of each sample tree is calculated from volume equations appropriate for the species. Board-foot volume is determined to minimum merchantable saw-log diameter in the tree, while cubic volume is determined to a 4-inch top diameter. Average volume distribution values are then used to allocate volume by log and half-log stem sections. Volume equations and volume distribution values used for southwestern ponderosa pine are shown in appendix A.

Volume suitable for log products is normally expressed in board feet, while volume of pulpwood is expressed in cubic feet. Either expression can be used with any product, however. For products normally considered by number or count, such as commercial poles, a piece count is maintained.

Product Grading and Volume Adjustment

Each sample tree is graded for the products specified by using a combination of recorded field data and program grading instructions. Grading instructions are based upon grading or quality specifications for each product (appendix A), and utilize the measured stem defect characteristics that form these grading criteria.

Tree size or estimated stem section diameter is used to judge initial suitability for each primary product. Trees or stem sections of acceptable size are graded for the products specified. Gross volume graded is then adjusted for defects that either prohibit use of the stem or stem section for the product, or reduce merchantable volume.

Commercial poles. —All sample trees 9.0 through 20.9 inches in diameter, for which a pole height has been field recorded, are considered for commercial poles. The programed evaluation procedure for a potential commercial pole proceeds as follows:

1. Verify acceptable stem size limits—9.0 through 20.9 inches d.b.h.
2. Accept recorded pole height from input field data.
3. Divide pole height by 8 to find 8-foot stem sections or half-logs involved. All fractions of sections are rounded upward (pole height/8 + 0.9) to assure that all sections wholly or partially contained in the pole are included.
4. Scan defect data for included stem sections for inadmissible or limiting defects.
   a. The stem is dropped from further consideration as a pole by the occurrence of
      —sweep (class 1 or class 2)
      —lightning scar
      —lean of 10° or more (class 2 or 3)
      —knots 4 inches or larger in diameter
      —major crook (class 2) or fork in any except the first or last stem section included in the pole height
      —indication of rot.
   b. Reduce merchantable pole height by one class (5 feet) if recorded defects include
      —fire or basal scar
      —fork or major crook (class 2) in the first or last stem section included in the pole height.
5. Pole count is accumulated by tree diameter class and pole height class.

Pole height is normally recorded in the field only for stems that do not have inadmissible defect. Programed defect screening is consequently a "double check" on the entry made in the field. The pole height recorded in the field will usually be accepted as correct pole potential for the stem.

Saw logs.—All sample trees of sawtimber size (11.0-inch d.b.h. and larger in ponderosa pine) are evaluated for saw log potential. Saw log grades are determined for lower logs, to a maximum of two logs or 32 feet of merchantable height. Grades are arbitrarily assigned to logs above that height. Gross saw log volume for each log in the tree is adjusted for the presence of scaling defects. The programed evaluation proceeds as follows:

1. Verify acceptable stem size—11.0-inch d.b.h. or larger, plus merchantable height of two or more half-logs.
2. Determine gross board-foot volume of the tree, and volume by 16-foot saw logs (including a top half-log where present), as previously described.
3. Estimate the grade of each saw log in the tree. Procedures for estimating grade depend upon the position of the log in the tree and the tree species or grading system used. Ponderosa pine saw logs are graded as follows:
   a. First 16-foot saw log:
      Scan recorded knot data by 8-foot section and face, starting with stem section 1, face 1, and proceeding in turn to faces 2, 3, and 4. For each face, accumulate a "clear 4-foot panel" count of:
      —no knots = count two (2)
      —one knot = count one (1)
      —two or more knots = count zero (0)
      Repeat for stem section 2, accumulating the panel count for the first two stem sections (totaling 16 feet of merchantable length). From the accumulated panel count, assign a log grade to the log as described in appendix A.
   b. Second 16-foot saw log:
      Grade the second full saw log in a tree by the same process. Add the clear panel count for stem section 3 to panel count for stem section 4, and assign a grade. Panel count for stem section 4 is limited to counting 2 for each clear face (coded 0), since knot numbers are not recorded. Where the third stem section is the last merchantable saw log volume in the tree (that is, merchantable tree height of three half-logs), the panel count for the one section is multiplied by two to determine grade.
   c. Third log and above:
      Assign lowest grade (grade 5) to all saw logs above 32 feet in the tree. (Alternatively, upper saw logs can be carried as ungraded volume, or can be assigned other grades based on available data.)
4. Adjust gross volume of each saw log for visual defect. Defects considered to reduce usable volume, and average scale deductions applied, are:

Defect	Scaling deduction 16-foot log (percent)	8-foot (top) log
a. Lightning scar (class 1) in tree	25	25
b. Lightning scar (class 2) in tree	50	50
c. Sweep (class 2) in tree	20	20
d. Fire scar (class 2) in tree (reduce butt log scale only)	13	0
e. Crook (any class) in either section of log	25	50
f. Fork in either section of log	25	50

5. Accumulate both gross and adjusted saw log volumes, by tree diameter class and log grade.

Veneer logs.—All 8-foot stem sections with an estimated diameter of 10 inches or more are potentially suitable for veneer. Veneer log quality evaluation is limited to the first three stem sections (24 feet), however, since knot data needed for grading are limited to these sections. Veneer log evaluation proceeds as follows:

1. Verify acceptable stem section diameter. In the absence of actual scaling diameters, stem sections in the first 24 feet considered to have scaling diameters of 10 inches or more are:

Tree d.b.h. class	Acceptable stem sections
12	1st section
14	1st, 2nd sections
16 or over	1st, 2nd, 3rd sections

2. Determine gross board-foot volume of the tree, and volume of acceptable 8-foot stem sections, as previously described. (Merchantable stem volume above 24 feet may also be calculated and carried as ungraded potential veneer log volume, if so desired.)
3. Estimate the grade of each potential veneer log in the tree. The grade of each 8-foot log (maximum of three logs) is estimated by scanning recorded knot type and size data for the four faces. Using size of largest dead and largest live knot, assign a grade as described in appendix A.

4. Adjust gross volume of each veneer log for visual defect. Defects considered to reduce usable volume, and average scale deductions applied, are:

Defect	Scaling deduction (percent)
a. Indication of rot in section (If by d.b.h. core, apply reduction to butt section only)	100
b. Crook (class 2) in section	100
c. Crook (class 1) in section	50
d. Fork in section	50
e. Lightning scar (class 2) in tree	50
f. Lightning scar (class 1) in tree	25
g. Fire scar (class 2) in tree (Apply reduction to butt section only)	25

Scan for occurrence of defects in the order shown. If total deduction reaches 100 percent, omit further scanning and apply 100 percent deduction.

5. Accumulate both gross and adjusted veneer log volumes by tree diameter class and log grade.

Stud logs.—Stud logs are typically processed through chipping headrig mills, or mills similarly equipped for the specialty manufacture of studs and dimension stock. The logs are often processed in 8-foot lengths, and are restricted in maximum diameter by the nature of the processing equipment. All 8-foot stem sections with an estimated scaling diameter of 17 inches or less are potentially suitable for stud logs. Stud log quality evaluation is limited to the first three stem sections (24 feet), however, because of the limitations in grading. Stud log evaluation proceeds as follows:

1. Verify acceptable stem section diameter. In the absence of actual scaling diameters, stem sections in the first 24 feet considered to have scaling diameters of 17 inches or less are:

Tree d.b.h. class	Acceptable stem sections
18 or under	1st, 2nd, 3rd sections
20	2nd, 3rd sections
22	3rd section
24 or over	None

2. Determine gross board-foot volume of the tree, and volume of acceptable 8-foot stem sections, as previously described.
3. Estimate the grade of each potential stud log in the tree. The grade of each 8-foot log (maximum of three logs) is estimated by scanning recorded knot count and size data for the four faces. Using size of largest dead and largest live knot, and knot count, assign a grade to the stud log as described in appendix A.
4. Adjust gross volume of each stud log for visual defect. Defects considered to reduce usable volume, and average scale deductions applied, are:

Defect	Scaling deduction (percent)
a. Indication of rot in section (If by d.b.h. core, apply reduction to butt section only)	100
b. Crook (class 2) in section	100
c. Crook (class 1) in section	50
d. Fork in section	50
e. Lightning scar (class 2) in tree	50
f. Lightning scar (class 1) in tree	25
g. Fire scar (class 2) in tree (Apply reduction to butt section only)	25

Scan for occurrence of defects in the order shown. If total deduction reaches 100 percent, omit further scanning and apply 100 percent deduction.

5. Accumulate both gross and adjusted stud log volumes, by tree diameter class and log grade.

Pulpwood.—The cubic volume of all trees, to a 4-inch top diameter, is potentially suitable for pulpwood. Pulpwood is a low-value product, however, and is usually obtained from trees or stem sections not suitable for other primary products. Pulpwood evaluation is consequently limited to cubic volume not accepted for other products, including top volume from minimum saw log top to a 4-inch diameter, plus any tree diameter classes or stem sections specifically excluded from other products. Pulpwood evaluation includes:

1. Specify tree diameter classes or stem sections (if any) excluded from prior product consideration: smaller tree diameter classes for which knot data are not recorded, tops to 4-inch d.i.b.
2. Determine gross cubic-foot volume of tree or stem sections designated for pulp. For sample trees 11.0 inches d.b.h. or over which have been evaluated for log products, only top volume will be required.
3. Adjust gross volume of each tree or section for visual defect. Defects considered to

reduce usable volume, and average volume deductions applied, are:

Defect	Volume deduction (percent)
a. Lightning scar (any class) in tree (including top)	100
b. Fire scar (any class) in tree (Applies only as reduction in butt section volume when entire tree is allocated to pulp)	50

Scan for occurrence of defects in the order shown. If total deduction reaches 100 percent, omit further scanning and apply 100 percent deduction.

4. Accumulate both gross and adjusted pulpwood volumes, by tree diameter class.

Other products.—Potential for other primary conversion products can also be evaluated as other products become of interest. An analysis of suitability and quality can be made for any product for which the recorded stem characteristics are grading criteria. Potential for a specific product can also be reevaluated after a grade change or revision of grading rules.

Calculation of Errors of Estimate

The adjusted gross volume of each stem section or tree graded is converted to a volume-per-acre estimate by means of the expansion or conversion factors appropriate for the sample. For all products, adjusted gross volume or piece count per acre is then accumulated by product, grade, and tree diameter class, for each random sampling unit.

Volumes per acre for each random sampling unit provide the basis for calculating precision of estimate for each product. The program uses a simple algorithm to compute standard error of the mean for each product and grade, by tree diameter class. The algorithm is most useful for simple random sampling and subsampling with units of equal size. It can also be used for proportional stratified sampling. Subsampling systems with substantially unequal sample units may require weighting procedures.

Calculated error terms are ultimately printed out with the volume estimates to which they correspond.

Form of the Output

The program prints out the product analyses in a series of tables. Each table presents potential by tree diameter class for one product and one or more grades within the product (appendix B). Average gross or adjusted volume per acre and standard error are printed out for each grade within each diameter class, and for the accumulated grade totals. Errors for totals are generally sufficient for most purposes.

As an integral part of the program, a permanent unit record is also developed for each sample tree. The unit record consists of all descriptive variables recorded in the field, and variables computed in the course of product evaluations (appendix A). Thereafter, output information can be obtained from the unit records for sample trees, classified or grouped by any recorded variables desired. Examples might be (1) volume of grade 3 and better saw logs in blackjack trees (as opposed to old-growth trees); (2) volume of acceptable veneer logs in trees with grade 5 saw logs in lower sections; (3) volume of acceptable veneer logs in trees acceptable as commercial poles.

For the Programer— Program Implementation

Program MULTI operates as an executive routine that provides for initial data card read-in, tree diameter class computation, initial tests of sample tree diameter against product size limit criteria, and preparation of a tape or disk file of tree records for further processing (fig. 2). Once the initial data have been tape or disk filed, MULTI is designed to make multiple passes through the data, executing options as specified on program control cards. MULTI calls on various subroutines to do the necessary grading, volume computations, and error calculations. An option is provided for writing a unit record tape file for each tree processed.

The program utilizes eight subroutines. Five are the product evaluation routines POLE, SAW, VENR, STUD, and PULP, with the names corresponding to the product being evaluated. The remaining three are VOLUM, which calculates board-foot and cubic-foot volumes of sample trees, CVOL, which converts sample volumes to volume per acre, and STDER, which calculates confidence limits around the means.

A complete printout of program MULTI, including all subroutines, is included as appendix B.

Program Data Cards

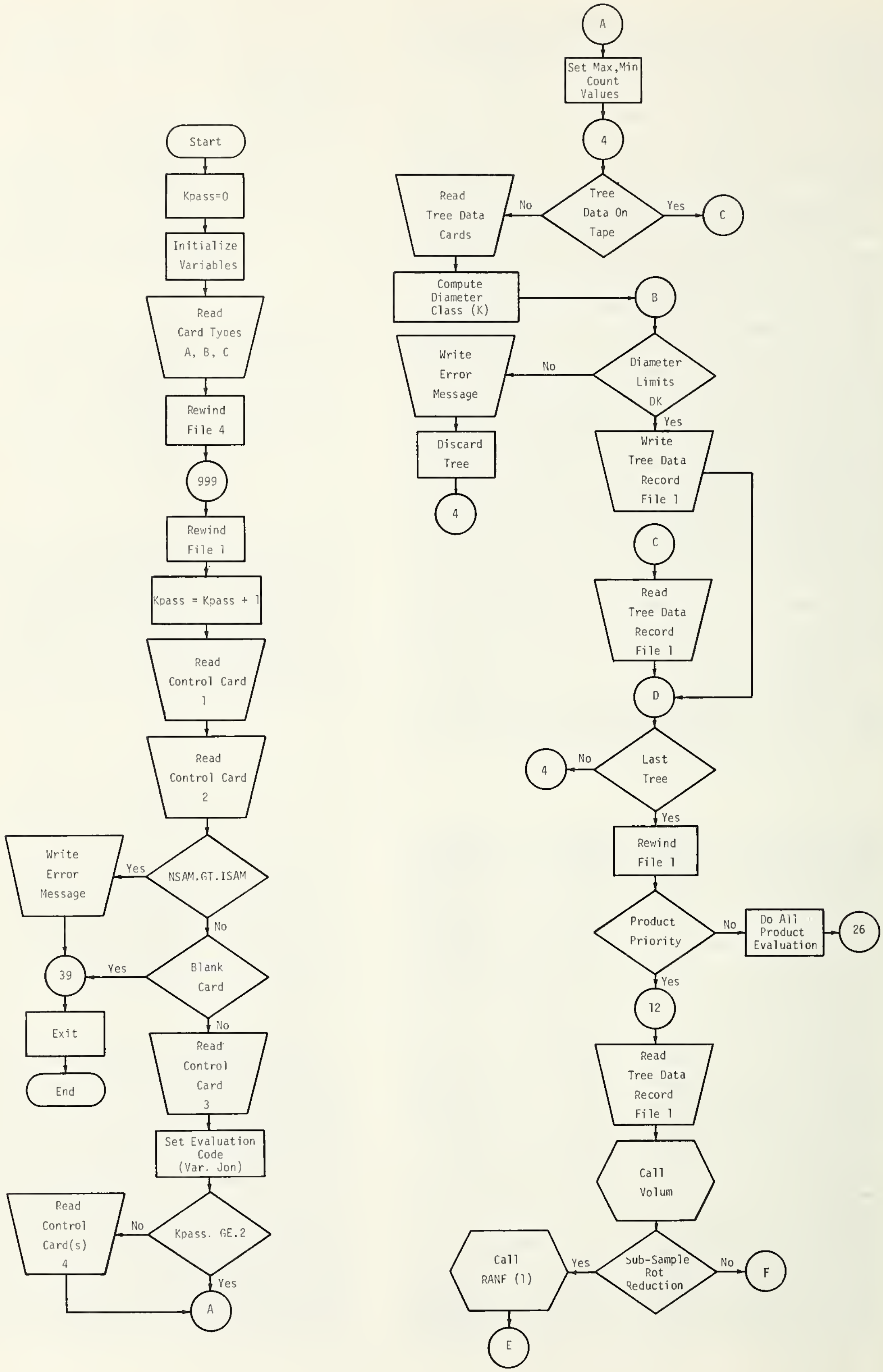
Program data cards type A, B, and C are read in at the beginning of the program. These cards provide the board-foot and cubic-foot volume distribution percentages needed to calculate volume by stem section (see appendix A).

Card type A includes a set of three cards containing cubic-foot volume distribution percentages for half-log (8-foot) stem sections, plus top to 4-inch d.i.b. The data are used to fill the array KCUV8(65). Card type B includes three cards containing board-foot volume distribution percentages, also by half-log (8-foot) stem section. The data are used to fill the array KBFV8(55). Card type C includes two cards containing board-foot volume distribution percentages for 16-foot saw logs. Data are used to fill the array KBFV16(29). In each case, volume distribution data are included for tree heights and log or half-log positions through 10 half-logs or five saw logs.

Complete program card data for southwestern ponderosa pine are shown in appendix A. The cards are coded as follows (format 26I3), with all values right-adjusted in the data fields:

Card type	Card number	Card columns	Percent value	Array element
A	A-1	1-3	65	L(1,1)
		4-6	35	L(1,T)
		7-9	50	L(2,1)
		etc.	etc.	etc.
		.	.	.
		.	.	.
		.	.	.
		73-75	10	L(6,5)
		76-78	8	L(6,6)
	A-2	1-3	3	L(6,T)
		4-6	26	L(7,1)
		7-9	18	L(7,2)
		etc.	etc.	etc.
		.	.	.
		.	.	.
		.	.	.
		73-75	8	L(9,7)
		76-78	6	L(9,8)
	A-3	1-3	4	L(9,9)
		4-6	2	L(9,T)
		7-9	19	L(10,1)
		etc.	etc.	etc.
		.	.	.
		.	.	.
		.	.	.
		34-36	4	L(10,10)
		37-39	2	L(10,T)
B	B-1	1-3	100	L(1,1)
		4-6	66	L(2,1)
		7-9	34	L(2,2)
		10-12	52	L(3,1)
		etc.	etc.	etc.
		.	.	.
		.	.	.
		.	.	.
		73-75	13	L(7,4)
		76-78	10	L(7,5)
	B-2	1-3	7	L(7,6)
		4-6	6	L(7,7)
		7-9	25	L(8,1)
		etc.	etc.	etc.
		.	.	.
		.	.	.
		.	.	.
		73-75	9	L(10,6)
		76-78	7	L(10,7)
	B-3	1-3	6	L(10,8)
		4-6	4	L(10,9)
		7-9	4	L(10,10)
C	C-1	1-3	100	L(1,1)
		4-6	75	L(1.5,1)
		7-9	25	L(1.5,1.5)
		10-12	64	L(2,1)
		etc.	etc.	etc.
		.	.	.
		.	.	.
		.	.	.
		73-75	35	L(5,1)
		76,78	27	L(5,2)
	C-2	1-3	20	L(5,3)
		4-6	13	L(5,4)
		7-9	5	L(5,5)

The volume distribution data, illustrated here for ponderosa pine, are input by means of cards to allow the user to select the set of distribution percentages that he wishes to use. If values for other species are desired, they can be substituted in the same manner. If additional values are required which exceed the dimensions of the arrays mentioned, array size should be increased and the source code modified or expanded in initial READ statements and in subroutine VOLUM. The data cards type A, B, and C are initial input only, and are not repeated for successive passes.


Start
Kpass=0
Initialize Variables
Read Card Types A, B, C
Rewind File 4
999
Rewind File 1
Kpass = Kpass + 1
Read Control Card 1
Read Control Card 2
NSAM.GT.ISAM
Yes
No
Write Error Message
Blank Card
39
Exit
End
Read Control Card 3
Set Evaluation Code (Var. Jon)
Kpass. GE.2
Read Control Card(s) 4
A
Set Max,Min Count Values
4
Tree Data On Tape
C
Read Tree Data Cards
Compute Diameter Class (K)
B
Diameter Limits DK
Write Error Message
Discard Tree
Write Tree Data Record File 1
Read Tree Data Record File 1
D
Last Tree
Rewind File 1
Product Priority
Do All Product Evaluation
26
12
Call Volum
Sub-Sample Rot Reduction
Call RANF (1)
E
F

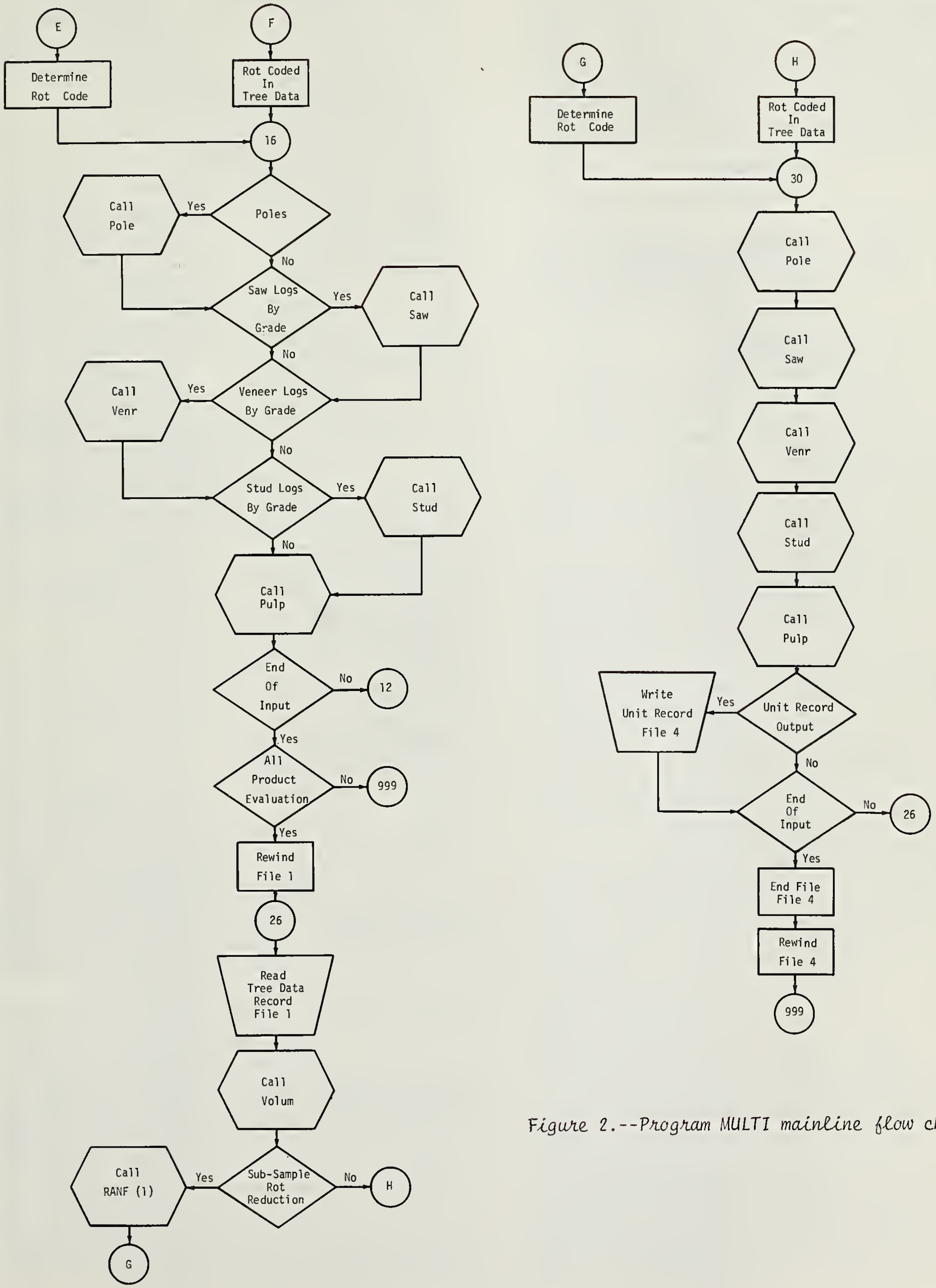


Figure 2.--Program MULTI mainline flow chart.

Program Control Cards

Program control and option parameters are read in on four control cards (card types 1 through 4) at the beginning of each problem and before each pass through the data. Program control cards are coded as follows, with all values right-adjusted in the data fields:

Card Type 1

Variable name	Card columns	Format	Description
PROB	1-80	8A10	Alphameric code to describe problem and user options.

Card Type 2

Variable name	Card columns	Format	Description
IN	1-5	I5	IN = 0, read tree data from cards. IN = 1, read tree data from tape.
NSAM	6-10	I5	Number of sample units. If "cluster" sampling is used, NSAM is number of clusters.
R	11-15	F5.3	If R is punched to any non-zero value, rot occurrence observed and recorded in a subsample of trees will be randomly extended to the entire sample. If rot occurrence data are available for all sample trees, R should be punched zero.
NPROD	16-20	I5	Number of products to be evaluated in each run. Maximum size of NPROD is 11, 1 pole grade, 4 saw log grades, 3 veneer grades, and 3 stud grades.
IP(I)	21-75	11I5	Sets the product priority order for product evaluation.
EXPFC	76-80	F5.0	EXPFC, when equal to some value other than zero, is a conversion factor to convert fixed-size plot sample values to per-acre basis. In plotless or point sampling, computed conversion factors are used, and EXPFC = 0.

Format (2I5, F5.3, 12I5, F5.0)

Card Type 3

Variable name	Card columns	Format	Description
JON	1-5	I5	JON = 1, specifies product evaluation on priority basis, each stem section evaluated only for highest priority product for which it is suited, following specified order of preference per IP(I), card type 2. JON = 2, specifies primary product evaluation in which each stem section is evaluated for all products for which it is suited. JON = 3, specifies both evaluations to be made.
KPOLE	6-10	I5	Trees to be evaluated for poles, KPOLE = 1; otherwise KPOLE = 0.
KSAW	11-15	I5	Trees to be evaluated for saw logs, KSAW = 1; otherwise KSAW=0.
KVENR	16-20	I5	Trees to be evaluated for veneer, KVENR = 1; otherwise KVENR = 0.
KSTUD	21-25	I5	Trees to be evaluated for stud logs, KSTUD = 1; other-KSTUD = 0.
KPULP	26-30	I5	Trees to be evaluated for pulpwood, KPULP = 1; otherwise KPULP = 0.
KOUT	31-35	I5	KOUT = 1, write on output unit record tape; KOUT = 0, skip this option. A unit record can be written only if JON = 2 or 3.
IBUG	36-40	I5	IBUG = 1, print out individual tree sta-

			tistics; IBUG = 0, skip this option. Use only for testing or debugging program as a large amount of output is generated.
KVOL	41-45	I5	KVOL = 1, compute and output gross volume tables; KVOL = 2, compute and output adjusted gross volume tables, volumes adjusted for visual scaling defects.
BAFV	48-55	F8.4	BAF value of the prism or angle gage used in plotless sampling.

Format (9I5, 2X, F8.4)
Sample input for a production run might be:
3-1-1-1-1-1-1-0-1-25.0000

Card Type 4

POINT(I)	1-80	16F5.0	Specifies the number of sampling points in each sample unit (NSAM). If more than 16 sample units are used, continue on subsequent cards. If cluster sampling is not used, POINT (I) should equal 1 for all entries. Decimal point need not be punched.

Product Priority Instructions

If products are to be evaluated on a priority basis, the desired order of priority must be specified by entries in the IP(I) fields, columns 21-75, of control card type 2. Entries refer to the specific subroutine being called:

1 Subroutine POLE
2 Subroutine SAW
3 Subroutine VENR
4 Subroutine STUD

If the desired priority is poles, followed by grades 1-3 saw logs, grades 1-3 veneer logs, grades 1-3 stud logs, and grade 5 saw logs, the IP(I) values would be coded as follows:

Variable	Column	Number	Product considered
NPROD	19-20	11	
IP(1)	25	1	Poles
IP(2)	30	2	Saw logs, grade 1
IP(3)	35	2	Saw logs, grade 2
IP(4)	40	2	Saw logs, grade 3
IP(5)	45	3	Veneer, grade 1
IP(6)	50	3	Veneer, grade 2
IP(7)	55	3	Veneer, grade 3
IP(8)	60	4	Studs, grade 1
IP(9)	65	4	Studs, grade 2
IP(10)	70	4	Studs, grade 3
IP(11)	75	2	Saw logs, grade 5

Computed Control Variables

A number of control variables are computed during the execution of the program. These variables are as follows:

KMAX	Equals the maximum diameter class in each data set.
KMIN	Equals the minimum diameter class in each data set.
IND(I) I=1, 10	Is an indicator which is set to **one** to indicate that a particular log or tree has been utilized for a priority product. If ITRHT is greater than 10, ITRHT=10.
KOUNT(I)	Equals the number of trees in each diameter class.
NBORE	Number of trees sampled for rot determination.
NROT	Number of sampled trees containing rot.
PROROT	Proportion of trees with rot as computed by NROT/NBORE. The program uses a random number generator to randomly extend the observed frequency of occurrence of rot to the entire sample. If rot occurrence data are available for all sample trees, the program provides an option (R=0) to bypass this procedure and use rot data directly. In either case, occurrence of rot should be coded 2 for proper program evaluation.

Tree Data Cards

Inventory data are recorded on punch cards, one card for each sample tree. The data included on the cards, and the coding and format required for the program, are described and illustrated in appendix A.

As many tree data cards as desired, within the limits of the disk or tape file, may be read in. Data may be entered in any order without regard to diameter class or sample number.

One blank card is used to signal the end of tree card input; two additional blank cards (read as type 1 and 2 control cards) will terminate the program after the desired computation and output is completed.

If additional runs or problems are to be executed on the filed data, repeat program control cards types 1, 2, and 3. Control card type 4 is not required for additional runs. As many sets of type 1, 2, and 3 control cards may be input as desired, with the last set being followed by two blank cards.

Subroutine POLE (PLHT2, POINT, TOTAL, ISAM, IMAX, PLHT1)

The arguments PLHT2, POINT, and TOTAL are dimensioned variables, the sizes set by the argument ISAM, which is equal to or greater than NSAM, the number of sample units used. The argument PLHT1 accumulates POLE counts by diameter class. The argument PLHT2 accumulates POLE counts by sample number and pole height class. In other product subroutines, each stem section is evaluated independently for the product being considered, and if JON = 1 accepted sections are withdrawn from consideration for subsequent products. In subroutine POLE, however, the use of a tree as a pole eliminates any consideration for other products and, conversely, use of any 8-foot section for another product eliminates the entire tree from being considered as a pole.

Subroutine SAW (VCNT, POINT, TOTAL, ISAM, IMAX)

The arguments VCNT, POINT, and TOTAL are dimensioned variables, the sizes set by ISAM and IMAX. ISAM must be equal to or greater than the total number of samples (NSAM), and IMAX must be equal to or greater than the largest diameter class in the data. The array VCNT is an accumulator for saw log volumes by diameter class and grade, POINT is a vector specifying the number of points (or subplots) in each sample, and TOTAL is an array for accumulation of volumes. This subroutine evaluates each sample tree between a minimum diameter class (KMIN) and maximum class (KMAX) that has at least one saw log (two 8-foot sections). Descriptive tree quality data are screened by 8-foot stem section, and a grade from the designated grading system is assigned each saw log. The grading system and method of evaluating grading criteria in ponderosa pine are described in appendix A. If priorities are established (JON = 1), selection of either or both half-logs for a higher priority will eliminate the full log from saw log consideration. Log volumes can be computed and printed out in terms of either gross volume (KVOL = 1) or volume adjusted for visual scaling defect (KVOL = 2), as previously discussed. Information is printed out by diameter class and total, for one log grade at a time if JON = 1 or for all grades at once if JON = 2.

Subroutine VENR (VCNT, POINT, TOTAL, ISAM, IMAX)

Input arguments for this subroutine are the same as those described for SAW. This subroutine evaluates each sample tree meeting initial diameter class specifications; it screens by 8-foot stem section and assigns a grade from the designated grading system (appendix A). Since grades are based on recorded knot data, grading is limited to the first three 8-foot stem sections in each tree. Log volume can be adjusted for visual scaling defects (KVOL = 2) if desired. If priorities are established (JON = 1), printouts will include only the three acceptable grades. A "grade 4" (material unacceptable because of knot size) is accumulated, however, and under option JON=2 will be printed out and listed in the tree unit record.

Subroutine STUD (VCNT, POINT, TOTAL, ISAM, IMAX)

The input arguments and operations of this subroutine are the same as those described for VENR. The same options and restrictions apply to grade evaluation (appendix A) and printouts for the product.

Subroutine PULP (PULPV, POINT, TOTAL, ISAM, IMAX)

The argument PULPV is a dimensioned variable of size ISAM. The other arguments are the same as in other subroutines. PULP accumulates cubic-foot volumes for all sample tree sections not accepted for other products, plus top volume from minimum saw log top to a 4-inch top diameter for each tree evaluated. All trees excluded because of d.b.h. less than 9 inches are also included in pulpwood totals. Pulpwood gross volumes can be adjusted for inadmissible visual defect (fire and lightning scar) as previously discussed, under the KVOL = 2 option.

Subroutine VOLUM (KCUV8, KBFV8, KBFV16, BAFV)

This subroutine calculates total merchantable board-foot and cubic-foot volume in each sample tree. Board-foot volume is calculated to minimum saw-log diameter and cubic-foot volume is calculated to a 4-inch top diameter. Volumes are allocated by log and half-log stem sections, by means of average volume distribution values. Tree volume equations and volume distribution percentages used for ponderosa pine are described in appendix A. The arguments KCUV8, KBFV8, and KBFV16 are dimensioned variables (volume distribution percentage values) read in by the program data cards.

If plotless or point sampling has been used, the subroutine also calculates expansion factors to convert sample values to per-acre values. An expansion factor is calculated for each sample tree, from the equation

$$EF = \frac{BAFV}{0.005454D^2}$$

where BAFV is input on control card type 3 and D^2 is tree d.b.h. squared.

Subroutine CVOL (VBL, EXPFC, EF)

This is a function subroutine used to convert product count or volume per tree or stem section to count or volume per acre, when plotless sampling has been used. Argument VBL is a dummy argument used to pass the sample value to be converted to the function CVOL. Argument EF is the point sample per-acre expansion factor calculated by subroutine VOLUM.

EXPFC (also called PRISM in some subroutines) is a factor to convert fixed-size plot sample values to per-acre values. EXPFC = 0 when plotless sampling is used.

Subroutine STDER (NSAM, Y, S, AMTRX, POINT)

This subroutine uses a simple algorithm to compute standard error of the mean for each product and grade, as indicated earlier. Calculated error terms are printed out with the volume estimates for the product. Arguments for the subroutine are:

Input

NSAM	Number of sample units
AMTRX	Data vector of size NSAM
POINT	Vector of size NSAM giving number of points or subplots per sample.

Return

Y	Mean of vector AMTRX
S	Standard error of vector AMTRX.

Unit Record Output

A permanent unit record, containing descriptive variables and a number of computed variables, is developed for each sample tree. The variables included in the record are described in appendix A. Unit record output is generated when program control card type 3 specifies JON = 2 or 3 and KOUT = 1. The record is written on external device logical file 4 (tape or disk storage) by a WRITE(4) LIST statement, and consists of strings of binary word values in the form in which they appear in storage. Each tree record consists of 105 binary words. An end-of-file is written after the last tree processed; a message is then printed that gives the number of records in the output file, plus a printout of the last tree record processed for check purposes.

It is assumed that the unit record output file would normally be used as input on the CDC 6400 system for further processing by the IOCS input-output routines. If this is not the case, it would be advisable to write the unit record output with a WRITE(4,FMT) LIST statement in the BCD mode. BCD tapes written with this statement can normally be read on a different computer, often with the normal FORTRAN input-output routines.

Program Operation and Limitations

Program MULTI is written in the FORTRAN Extended Language Version 1.0, an extension of the USASI FORTRAN language, for the Control Data 6400 computer system. Operation of the program requires a central processor, a card reader, output line printer (assigned logical file 3) and two external tape or disk storage devices (assigned logical files 1 and 4).

The program contains error messages which provide information to help the user correct the input data. There are no recovery points in the program. When an abort or execution failure occurs, all volume accumulations to time of failure are lost and the program must be restarted from the beginning.

Maximum diameter class and sample size are set in the data statement, DATA IMAX, ISAM/40.4/. Dimensioned variables SAWV, VENRV, STUDV, PULPV, VCNT, PLHT2, TOTAL, and POINT contain as their first sub-

script the maximum sample size allowed. Because all of these variables except VCNT are intermeshed with an EQUIVALENCE statement, their first dimensions must be the same and should equal ISAM. The last dimension of SAWV, VENRV, and VCNT must equal IMAX. Any change in ISAM and/or IMAX requires a program coding change in all the variables mentioned. Other dimensioned variables do not require changes due to changes in sample number or maximum diameter class.

A test version of program MULTI, with maximum sample size = 130 and maximum diameter class = 34, required a field length of $105,700_8$ or core storage of 36_{10} K to load the program. A CDC 6400 computer system with $140,000_8$ or 50_{10} K available can possibly accommodate maximum variable combinations to sample size = 150 and diameter class = 40. Larger combinations may require overlay subroutines.

Loading procedure

The order for loading the program is:

1. Computer center control cards.
2. MULTI-Main and all subroutines.
3. Program data cards, types A, B, and C (a set of eight cards)
4. Program control cards, types 1, 2, 3, and 4.
5. Individual tree data cards.
6. Blank card to signal end of tree data.
7. Two additional blank cards if run is to terminate after first pass, or
   Repeat program control cards, types 1, 2, and 3 as many times as desired, one set for each pass.
8. Two blank cards to terminate job, final pass.

Literature Cited

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Gaines, Edward M.
1962. Improved system for grading ponderosa pine and sugar pine saw logs in trees. U.S. Forest Serv. Pacific Southwest Forest and Range Exp. Sta. Tech. Pap. 75, 21 p. Berkeley, Calif.

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1963. Volume, taper, and related tables for southwestern ponderosa pine. U.S. Forest Serv. Res. Pap. RM-2, 24 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

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APPENDIX A

Field Inventory Data

Field inventory methods are described in Barger and Ffolliott (1970). Field inventory data described here are those taken in inventorying ponderosa pine. For other species or primary products, some modification of the data recorded may be desirable. For the evaluation program MULTI, one data card is punched for each sample tree, following the coding and format described:

Variable name	Card columns	Format	Description
—	1-2	2X	Blank or identification data.
ISTRT	3-4	I2	Sample number, range 01 to 99.
IDMY	5-11	I7	Dummy variable, can be used for ID data.
DBH	12-16	F5.2	Tree d.b.h., punch decimal point, XX.XX.
IPLHT	18-19	I2	Pole height, recorded as maximum 5-foot height class obtainable (25', 30', 35', etc.).
ISWP	21	I1	Sweep entered as 1 (minor) or 2 (major).
IPCR	22	I1	Number of half-log in which crook occurs.
ICRK	23	I1	Crook entered as 1 (minor) or 2 (major).
IPFK	24	I1	Number of half-log in which fork occurs.
IFRK	25	I1	Coded as 1 if fork exists.
IFS	26	I1	Fire scar entered as 1 (minor) or 2 (major).
ILS	27	I1	Lightning scar entered as 1 (minor) or 2 (major).
KNOT (1,1,1)	29	I1	Number of knots in face 1, section 1.
KNOT (1,1,2)	30	I1	Size of largest live knot to nearest inch, face 1, section 1.
KNOT (1,1,3)	31	I1	Size of largest dead knot to nearest inch, face 1, section 1.
KNOT (1,2,N)	32-34	3I1	Repeat for face 2, section 1, N=1,2,3.
KNOT (1,3,N)	35-37	3I1	Repeat for face 3, section 1, N=1,2,3.
KNOT (1,4,N)	38-40	3I1	Repeat for face 4, section 1, N=1,2,3.
KNOT (2,M,N)	43-54	12I1	Same knot data recorded by 8-foot section and face for **second** section (or to minimum merchantable top diameter).
KNOT (3,M,N)	57-68	12I1	Same knot data recorded by 8-foot section and face for **third** section (or to minimum merchantable top diameter).
I24P			For the fourth 8-foot section (24' - 32'), only presence or absence of clear 8-foot faces is entered as:
I24P(1)	71	I1	Face 1: 0 if clear, 1 if knots occur.
I24P(2)	72	I1	Face 2: 0 if clear, 1 if knots occur.
I24P(3)	73	I1	Face 3: 0 if clear, 1 if knots occur.
I24P(4)	74	I1	Face 4: 0 if clear, 1 if knots occur.
ITRHT	76-77	I2	Tree height, recorded as total half-logs or 8-foot sections to the minimum saw log top diameter. If tree height is recorded in total feet or in 16-foot sections, a conversion to half-log height is required.
LEAN	79	I1	Lean, recorded by 5 degree classes (nearest class) as: 0 - Less than 3 degrees

Variable name	Card columns	Format	Description
			1 - 5 degrees 2 - 10 degrees 3 - 15 degrees or more
IROT	80	I1	Rot, as observed in subsample by means of increment cores or other indicators, recorded as: 0 - not sampled 1 - sampled, no rot 2 - sampled, rot

Card format (2XI2, I7, F5.2, 1xI2, 1x7I1, 1x12I1, 2x12I1, 2x12I1, 2x4I1, 1xI2, 1x2I1)

Sample Tree Volume Determination

Cubic-foot Volume Determination

Determine tree height in half-logs (8-foot sections) to minimum merchantable saw log diameter. If only total tree height has been recorded, estimate half-log height from total height (Van Deusen 1967).

Calculate total merchantable cubic-foot volume of sample tree to 4.0-inch top, by equation. For tree height in 16-foot logs to nearest half-log (H) and d.b.h. outside bark (D), equations for southwestern ponderosa pine are (Myers 1963):

(1) Tree d.b.h. under 19.0 —

D^2H 800 or less:

$$V = 0.046000\ D^2H + 6.800000$$

D^2H over 800 :

$$V = 0.044204\ D^2H + 8.266000$$

(2) Tree d.b.h. over 19.0 —

D^2H 1,000 or less :

$$V = 0.050666\ D^2H + 5.866800$$

D^2H over 1,000 :

$$V = 0.045736\ D^2H + 10.857212$$

Nineteen inches is the assumed breaking point between blackjack and old-growth trees.

Determine volume distribution among stem sections of the tree. Apply percentages to total tree volume to estimate volume of sections. Average cubic volume distribution in southwestern ponderosa pine of specified half-log height is:

Tree height half-logs	Half-log position in tree 1	2	3	4	5	6	7	8	9	10	Top to 4.0-inches d.i.b.
Number	- - - Percent of total cubic-foot tree volume - - -										
1	65										35
2	50	31									19
3	43	29	17								11
4	38	27	17	11							7
5	32	24	17	13	9						5
6	28	21	16	14	10	8					3
7	26	18	15	13	10	9	6				3
8	24	16	14	12	10	9	7	5			3
9	22	15	13	12	10	8	8	6	4		2
10	19	15	12	11	10	8	8	6	5	4	2

Board-foot volume determination

Determine tree height in half-logs (8-foot stem sections) to minimum merchantable saw-log diameter. If only total tree height has been recorded, estimate half-log height from total height.

Calculate total merchantable board-foot volume of sample tree to minimum merchantable top diameter (variable), by equation. For tree height in 16-foot logs to nearest half-log (H) and d.b.h. outside bark (D), Scribner rule equations for southwestern ponderosa pine are (Myers 1963):

(1) Tree d.b.h. under 19.0—

D^2H 800 or less:

$$V = 0.224793\ D^2H + 8.165600$$

D^2H over 800:

$$V = 0.300081\ D^2H - 52.090112$$

(2) Tree d.b.h. 19.0 or over —

D^2H 1,130 or less:

$$V = 0.275784\ D^2H - 5.091250$$

D^2H over 1,130:

$$V = 0.326427\ D^2H - 62.962331$$

Nineteen inches is the assumed breaking point between blackjack and old-growth trees.

Determine volume distribution among stem sections of the tree. Average board-foot volume distribution in southwestern ponderosa pine of specified log height is indicated below. For saw logs, normally expressed in terms of 16-foot logs and half-logs, refer to the first tabulation. For veneer and stud logs or other log products utilized in 8-foot lengths, refer to the second tabulation. Apply percentages to total tree volume to estimate volume of individual logs or sections.

Tree height in		16-foot saw log position in tree								
Logs	Half-logs	1	1.5	2	2.5	3	3.5	4	4.5	5
Number		- Percent of total board-foot tree volume -								
1	2	100								
1.5	3	75	25							
2	4	64	--	36						
2.5	5	58	--	32	10					
3	6	49	--	33	--	18				
3.5	7	41	--	32	--	19	8			
4	8	44	--	31	--	17	--	8		
4.5	9	39	--	29	--	19	--	10	3	
5	10	35	--	27	--	20	--	13	--	5

Tree height, half-logs	8-foot half-log position in tree									
	1	2	3	4	5	6	7	8	9	10
Number	Percent of total board-foot tree volume									
1	100									
2	66	34								
3	52	32	16							
4	43	30	18	9						
5	36	26	18	12	8					
6	31	23	18	14	9	5				
7	28	20	16	13	10	7	6			
8	25	18	15	13	10	9	6	4		
9	23	16	14	12	10	9	7	5	4	
10	21	15	13	11	10	9	7	6	4	4

Product Specifications and Grades

Ponderosa Pine Commercial Poles

All trees 9.0 through 20.9 inches in diameter and of acceptable pole form are considered potential poles. Grading specifications for commercial poles were adapted from those of the American Standards Association (1963).

Inadmissible defects in commercial poles include

—sweep (deviation greater than 1/3 d.b.h.)
—major crook (deviation greater than 1/2 pole diameter at crook)
—knots larger than 4 inches in diameter (dead or green)
—knot whorls or clusters aggregating more than 8 inches of knot diameter within 1 linear foot
—fork
—heart rot
—lightning scar
—fire scar
—compression wood (considered present in stems leaning 10° or more)

For trees meeting minimum merchantable specifications, stem length to the first limiting defect, such as length to first inadmissible knot, is field recorded. Such defects as fork, crook, and fire scar, if located near the butt or top of the stem, may not eliminate the pole but require a reduction of acceptable pole length.

Programed grading procedures scan defect data for stem sections included in pole height, and either verify or change recorded pole height as necessary.

Ponderosa Pine Saw Logs

All trees 11.0 inches d.b.h. and larger are considered sawtimber trees, and logs 8.0 inches and larger in scaling diameter are evaluated as saw logs.

All grading specifications apply to 16-foot log lengths. The same specifications apply to shorter logs, in proportion to their length.

All logs meeting the minimum merchantability standards are graded by the improved grading system for ponderosa pine logs (Gaines 1962).

Abbreviated grading specifications are as follows:

	Defects Permitted	
Grade	Primary (log knots)	Secondary (scar, etc.)
1	One log knot not over ½ inch in diameter.	Confined to three 4-foot panels or less.
2	Confined to four 4-foot panels or less.	Secondary plus primary confined to six 4-foot panels.
3	Six 4-foot panels free of all grading defects.	
4	(Logs of the type described by grade 4 of this system do not generally occur in southwestern ponderosa pine; consequently, the grade is omitted from consideration.)	
5	All other logs with net scale of one-third or more of gross scale.	

Programed grading instructions estimate the number of clear 4-foot panels in each log, based on recorded knot data. Accumulated panel count is used to assign a log grade to the log, as follows:

Clear panels, 1/4 circumference x 4 feet	Log grade
15-16	1
12-14	2
5-11	3
Less than 5	5

Ponderosa Pine Veneer Logs

Logs 10.0 inches and larger in scaling diameter are considered potential veneer logs.

All grading specifications apply to 8-foot log lengths.

Logs that meet the minimum merchantability requirements for veneer logs are graded according to the following arbitrary grading rules for ponderosa pine veneer logs, written for use in multiproduct inventory analysis.

GRADE I Veneer logs from which a high proportion of grade A and B veneer can probably be recovered.

Grade Specifications

Dead knots - none allowed.

Green knots - allowed up to 2 inches in diameter.

GRADE II Veneer logs from which a high proportion of grade C veneer can probably be recovered.

Grade Specifications

Dead knots - allowed up to 2 inches in diameter.

Green knots - allowed up to 2 inches in diameter.

GRADE III Veneer logs from which a high proportion of grade D veneer can probably be recovered.

Grade Specifications

Dead knots - allowed up to 3 inches in diameter.

Green knots - allowed without size limit.

UNACCEPTABLE Logs identified as "grade 4" for computer programing and output purposes.

Dead knots - 4 inches or more in diameter.

Ponderosa Pine Stud Logs

Logs 6.0 through 16.9 inches in scaling diameter are considered potential stud logs.

All grading specifications apply to 8-foot log lengths.

Logs that meet basic size requirements for stud logs are graded according to the following arbitrary grading rules for ponderosa pine stud logs, written for use in multiproduct inventory analysis.

GRADE I Stud logs from which a high proportion of SELECT and CONSTRUCTION grade studs can probably be recovered.

Grade Specifications

Dead knots - allowed to 1 inch in diameter.

Green knots - allowed to 2 inches in diameter.

Total number of knots - cannot exceed 16.

GRADE II Stud logs from which a high proportion of STANDARD grade studs can probably be recovered.

Grade Specifications

Dead knots - allowed to 2 inches in diameter.

Green knots - allowed to 2 inches in diameter.

Total number of knots - cannot exceed 32.

GRADE III Stud logs from which a high proportion of UTILITY and ECONOMY grade studs can probably be recovered.

Grade Specifications

Dead knots - allowed to 2 inches in diameter.

Green knots - allowed to 3 inches in diameter.

Total number of knots - unlimited.

UNACCEPTABLE Logs identified as "grade 4" for computer programing and output purposes.

Dead knots - 3 inches or more in diameter.

Green knots - 4 inches or more in diameter.

Sample Tree Unit Record

The unit record for each sample tree includes the following descriptive and computed variables applicable to the tree, printed in the following order:

Tree diameter class (K)
Sample number (ISTRT)
Sample identification data (IDMY)
Tree d.b.h. (DBH)
Commercial pole merchantable height (IPLHT)
Defect occurrence:
- Sweep (Class 1, 2: ISWP)
- Crook (Location and Class 1, 2: IPCR, ICRK)
- Fork (Location and occurrence: IPFK, IFRK)
- Fire scar (Class 1, 2: IFS)
- Lightning scar (Class 1, 2: ILS)

Knot data:
- Count, size, first stem section KNOT (N,L,D)
- Count, size, second stem section KNOT (N,L,D)
- Count, size, third stem section KNOT (N,L,D)
- Clear face count, fourth stem section I24P(N)

Half-log merchantable tree height (ITRHT)
Lean (Class 1, 2, 3: LEAN)
Indication of internal rot (IROT)
Pole selector indicator (0 = No, 1 = Yes) (KP)
Total tree cubic-foot volume to 4-inch top (TCFV)
Total tree board-foot volume to saw log top (TBFV)
Vol./Acre expansion factor used for tree (EF)
Volume of saw logs (board feet), by log position and grade
- BFSW(1,1), grade 1, log position 1
- BFSW(2,2), grade 1, log position 2
- BFSW(1,3), grade 1, log position 3
- BFSW(1,4), grade 1, log position 4
- BFSW(1,5), grade 1, log position 5
- Repeat for saw log grades 2, 3, 4 (grade 4 = 5)

Volume of veneer logs (board feet), by log position and grade
- BFVN(1,1), grade 1, log position 1
- BFVN(1,2), grade 1, log position 2
- BFVN(1,3), grade 1, log position 3
- Repeat for veneer log grades 2, 3, 4 (grade 4 = unacceptable)

Volume of stud logs (board feet), by log position and grade
- BFST(1,1), grade 1, log position 1
- BFST(1,2), grade 1, log position 2
- BFST(1,3), grade 1, log position 3
- Repeat for stud log grades 2, 3, 4 (grade 4 = unacceptable)

Volume of pulpwood (cubic feet); top piece and other sections
- CFPL(1), in top, saw log to 4-inch top
- CFPL(2), all sections not acceptable for other products

APPENDIX B

```
      PROGRAM MULTI
     1(INPUT,OUTPUT,TAPE5=INPUT,TAPE3=OUTPUT,TAPE1,TAPE4)
C-----COMPUTER PROGRAM TO CONVERT MULTIPRODUCT INVENTORY DATA TO YIELD
C-----BY PRODUCT
C-----                          BY
C-----        JACK D. HEIDT AND DONALD A. JAMESON
C-----ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
C-----                        PROGRAM CONTROL CARDS
C-----
C-----DATA CARD(S) TYPE A
C-----
C-----A SET OF THREE CARDS TO INPUT THE PERCENT OF TOTAL CUBIC FOOT VOL.
C-----BY 8-FT. STEM SECTIONS. SEE PROG. DESCRIPTION FOR ORDER AND FORMAT
C-----
C-----DATA CARD(S) TYPE B
C-----
C-----A SET OF THREE CARDS TO INPUT THE PERCENT OF TOTAL BOARD FOOT VOL.
C-----BY 8-FT. STEM SECTIONS. SEE PROG. DESCRIPTION FOR ORDER AND FORMAT
C-----
C-----DATA CARD(S) TYPE C
C-----
C-----A SET OF TWO CARDS TO INPUT THE PERCENT OF TOTAL BOARD FOOT VOL.
C-----BY 16-FT. STEM SECTIONS(SAWLOGS). SEE PROG. DESCRIPTION FOR ORDER
C-----AND FORMAT
C-----
C-----CONTROL CARD TYPE 1
C-----
C-----PROB(I)=PROBLEM IDENTIFIER
C-----
C-----CONTROL CARD TYPE 2
C-----
C-----IN=0 INDICATES TREE DATA TO BE INPUT FROM CARDS
C-----IN=1 INDICATES TREE DATA TO BE INPUT FROM TAPE
C-----NSAM=NUMBER OF SAMPLE UNITS IF CLUSTER SAMPLING IS USED, NSAM IS
C-----THE NUMBER OF CLUSTERS.
C-----FOR PROPORTIONAL ROT REDUCTION, R=NON-ZERO
C-----NPROD=NUMBER OF PRODUCTS TO BE EVALUATED
C-----IP(I)=PRODUCT PRIORITY
C-----IF USING PRIMARY PRODUCT SELECTION CRITERIA IP(I) SPECIFIES ORDER
C-----OF PRODUCT PRIORITIES
C-----FOR PLOTLESS CRUISING, EXPFC=0. FOR FIXED PLOT SIZE CRUISING,
C-----EXPFC IS A CONVERSION FACTOR TO ADJUST RESULTS BASED ON PLOT SIZE
C-----
C-----CONTROL CARD TYPE 3
C-----
C-----JON=1 INDICATES PRIMARY PRODUCT SELECTION CRITERIA
C-----JON=2 INDICATES SAMPLE WILL BE EVALUATED FOR ALL PRODUCTS
C-----JON=3 GIVES BOTH TYPES OF EVALUATION
C-----FOR POLE STUDY, KPOLE=1, TO OMIT KPOLE=0
C-----FOR SAWLOG STUDY KSAW=1, TO OMIT KSAW=0
C-----FOR VENEER STUDY, KVENR=1, TO OMIT KVENR=0
C-----FOR STUD LOG STUDY, KSTUD=1, TO OMIT KSTUD=0
C-----FOR PULP STUDY KPULP=1,TO OMIT KPULP=0
C-----FOR UNIT RECORD OUTPUT TAPE,JON=2OR3,KOUT=1,TO OMIT KOUT=0
C-----FOR INDIVIDUAL TREE COMPUTATIONS IBUG=1,TO OMIT IBUG=0
C-----FOR GROSS VOL OUTPUT KVOL=1,FOR ADJUSTED GROSS VOL OUTPUT KVOL=2
C-----UNIT RECORD OUTPUT IS ACCUMULATED ONLY FOR GROSS VOL, KVOL=1.
C-----BAFV=BASAL AREA FACTOR VALUE OF THE PRISM OR ANGLE GAUGE USED IN
C-----PLOTLESS CRUISING
C-----
C-----CONTROL CARD TYPE 4
C-----
C-----THIS CARD WILL BE READ ONLY ON INITIAL PASS THROUGH DATA
C-----POINT(I) = NUMBER OF PLOTS PER CLUSTER
C-----USE ADDITIONAL CARDS IF NEEDED
C-----IF CLUSTER SAMPLING IS NOT USED, POINT(I)=1 FOR ALL ENTRIES
C-----
C-----COMPUTED CONTROL VARIABLES
C-----
C-----KMAX=MAXIMUM DIAMETER CLASS IN DATA
C-----KMIN=MINIMUM DIAMETER CLASS IN DATA
C-----IND(I)=PRIOR USE INDICATOR
C-----KOUNT(I)=NUMBER OF TREES PER DIAMETER CLASS
C-----NBORE= NUMBER OF TREES BORED
C-----NROT = NUMBER OF BORED TREES WITH ROT
C-----
C-----                     INDIVIDUAL TREE DATA CARDS
C-----
C-----THESE CARDS WILL NOT BE READ IF IN.NE.0
C-----ISTRT=SAMPLE NUMBER
C-----IDMY=DUMMY VARIABLE,CAN BE USED FOR TREE ID INFORMATION
C-----DBH=DIAMETER BREAST HIGH
C-----IPLHT=POLE HEIGHT
C-----ISWP=SWEEP CLASS
C-----IPCR=CROOK LOCATION
C-----ICRK=CROOK CLASS
C-----IPFK=FORK LOCATION
C-----IFRK=FORK CLASS
C-----IFS=FIRE SCAR
C-----ILS=LIGHTNING SCAR
C-----KNOT(K,L,M)=KNOT NUMBER AND SIZE
C-----I24P(I)=CLEAR FACE CLASSES
C-----ITRHT=TREE HEIGHT IN HALF LOGS
C-----LEAN=LEAN CLASS
C-----IROT=ROT CLASS
C-----END TREE DATA CARD INPUT WITH ONE BLANK CARD
C-----
C-----INDICATORS INTERNAL IN THE PROGRAM
C-----VARIABLE DIMENSIONS OF ALL DIMENSIONED VARIABLES ARE SHOWN IN
C-----DATA STATEMENT, SEE SUBROUTINE DIMENSIONS FOR GUIDE
C-----NO CHANGES ARE REQUIRED IN SUBR. AS VARIABLE DIMENSIONS ARE USED
C-----ISAM EQUAL TO OR GREATER THAN NSAM
C-----IMAX EQUAL TO OR GREATER THAN KMAX
C-----FOR UNIT RECORD OUTPUT,REQUEST TAPE4 FOR OUTPUT. HAS EOF MARK END
C-----
      DIMENSION SAWV(4,4,40),VENRV(4,4,40),STUDV(4,4,9),PLHT1(15,20),
     1PLHT2(4,15),TOTAL(4,4),POINT(4),PULPV(4),KCUV8(65),KBFV8(55),
     2KBFV16(29)
C
      COMMON KNOT(3,4,3),I24P(4),IP(11),IND(10),KOUNT(50),Y(15),S(15),
     1PROB(8),PCUV8(11),PBFV8(10),PBFV16(5),BFSW(4,5),BFVN(4,3),
     2BFST(4,3),CFPL(2),NPROD,KMIN,KMAX,NSAM,K,ISTRT,DBH,IPLHT,ISWP,
     3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUD,JON,
     4LAST,TCFV,TBFV,IBUG,ICARD,PRISM,KP,IDMY,KVOL,EF
C
      EQUIVALENCE (SAWV(1,1,1),PLHT2(1,1)), (SAWV(1,1,5),TOTAL(1,1)),
     1(SAWV(1,1,6),PULPV(1)), (SAWV(1,1,7),POINT(1)), (SAWV(1,1,9),VENRV
     2(1,1,10))
C
      DATA IMAX,ISAM/40,4/
      KPASS=0
      NREC=0
      KP=0
      EF=0.0
      DO 100 I=1,4
      DO 100 J=1,3
      BFVN(I,J)=0.0
  100 BFST(I,J)=0.0
      DO 102 I=1,4
      DO 102 J=1,5
  102 BFSW(I,J)=0.0
      CFPL(1)=0.0
      CFPL(2)=0.0
C-----
C-----READ VOLUME PERCENTAGE TABLES FOR CUFT-8,BRFT-8, AND BRFT-16.
C-----INPUT CARDS, TYPES A,B,C.
C-----
      READ(5,106) (KCUV8(I),I=1,65)
  106 FORMAT(26I3/(26I3))
      READ(5,106) (KBFV8(I),I=1,55)
      READ(5,106) (KBFV16(I),I=1,29)
      REWIND 4
  999 REWIND 1
      KPASS=KPASS + 1
C
C-----READ CONTROL CARDS  CARD TYPES 1,2,3,4
C
      READ (5,40) (PROB(I),I=1,8)
      READ (5,42) IN,NSAM,R,NPROD,(IP(I),I=1,NPROD),EXPFC
      IF (NSAM.GT.ISAM) WRITE (3,41) NSAM
      IF (NSAM.GT.ISAM) GO TO 39
      IF (NSAM.EQ.0) GO TO 39
      PRISM=EXPFC
      READ(5,43) JON,KPOLE,KSAW,KVENR,KSTUD,KPULP,KOUT,IBUG,KVOL,BAFV
      JONREF=JON
      JON=AMINO(JON,1)
      IF(KPASS.GE.2) GO TO 2
      READ (5,44) (POINT(I),I=1,NSAM)
    2 KMAX=0
      KMIN=100
      NROT=0
      NBORE=0
      PROROT=0.0
      DO 3 K=2,50,2
    3 KOUNT(K)=0
    4 IF (IN.NE.0) GO TO 5
C-----
C-----READ TREE DATA CARDS. THE FORMAT AND INPUT LIST MAY BE CHANGED TO
C-----AGREE WITH USERS CODED DATA. ALL VARIABLES NOT INCLUDED IN USERS
C-----INPUT LIST SHOULD BE SET TO ZERO FOR FURTHER USE IN THE PROGRAM
C-----
      READ(5,45)ISTRT,IDMY,DBH,IPLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,ILS,((
     1(KNOT(L,M,N),N=1,3),M=1,4),L=1,3),(I24P(I),I=1,4),ITRHT,LEAN,IROT
      IF(ITRHT.GT.10) ITRHT=10
C-----
C-----COMPUTE DIAMETER CLASS
C-----
      K=DBH/2.0+0.5
      K=K*2
      IF (K.GT.IMAX) WRITE (3,46) DBH
      IF (K.GT.IMAX) GO TO 4
      IF (ISTRT.GT.ISAM) WRITE (3,47) ISTRT
      IF (ISTRT.GT.ISAM) GO TO 4
C-----
C-----RECORD TREE DATA ON TAPE
C-----
      WRITE(1)K,ISTRT,IDMY,DBH,(PLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,ILS,((
     1(KNOT(L,M,N),N=1,3),M=1,4),L=1,3),(I24P(I),I=1,4),ITRHT,LEAN,IROT
      GO TO 6
C-----
C-----IF DATA IS TAPE FILED, READ FROM TAPE
C-----
    5 READ(1)K,ISTRT,IDMY,DBH,IPLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,ILS,(((
     1KNOT(L,M,N),N=1,3),M=1,4),L=1,3),(I24P(I),I=1,4),ITRHT,LEAN,IROT
    6 IF (DBH) 11,11,7
    7 KOUNT(K)=KOUNT(K)+1
      IF (IROT.GT.0) NBORE=NBORE+1
      IF (IROT.GT.1) NROT=NROT+1
      IF (K-KMAX) 9,9,8
    8 KMAX=K
    9 IF (K-KMIN) 10,4,4
   10 KMIN=K
      GO TO 4
   11 REWIND 1
      IF (R.NE.0) PROROT=FLOAT(NROT)/FLOAT(NBORE)
      ICARD=0
      GO TO (12,26,12), JONREF
C-----
C-----BEGIN PRODUCT PRIORITY ROUTINE
C-----
   12 LAST=1
      IF (IBUG.EQ.1) WRITE (3,48) PROROT
C-----
C-----READ AND EVALUATE DATA BY PRODUCTS
C-----
      DO 25 KX=KMIN,KMAX,2
      LIM=KOUNT(KX)
      IF (LIM.EQ.0) GO TO 25
      DO 24 J=1,LIM
      DO 13 I=1,10
   13 IND(I)=0
      READ(1)K,ISTRT,IDMY,DBH,IPLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,ILS,(((
     1KNOT(L,M,N),N=1,3),M=1,4),L=1,3),(I24P(I),I=1,4),ITRHT,LEAN,IROT
      IF(ITRHT.LE.0) WRITE(3,471) ITRHT,IDMY
      IF(ITRHT.LE.0) GO TO 24
      CALL VOLUM (KCUV8,KBFV8,KBFV16,BAFV)
C-----
C-----IF RANDOM NUMBER GENERATOR(RANF(I)) IS NOT USED TO DETERMINE SUB-
C-----SAMPLE FOR ROT REDUCTION,INSERT A GO TO 16 BRANCH CARD HERE. R=0
C-----
C     GO TO 16
      IF (RANF(1).LT.PROROT) 14,15
   14 IROT=2
      GO TO 16
   15 IROT=0
   16 IF (IBUG.EQ.0) GO TO 18
      ICARD=ICARD+1
      WRITE(3,49) ICARD,ISTRT,POINT(ISTRT),EF,K,DBH,IPLHT,ITRHT,ISWP,
     1LEAN,ICRK,IPCR,IFRK,IPFK,IFS,ILS,IROT,(I24P(IM),IM=1,4)
      DO 17 L=1,3
      DO 17 M=1,4
   17 WRITE (3,50) L,M,(KNOT(L,M,N),N=1,3)
   18 IF ((KX.EQ.KMAX).AND.(J.EQ.LIM)) LAST=3
      NSAW=0
      NVENR=0
      NSTUD=0
      DO 23 I=1,NPROD
      ISUB=IP(I)
      GO TO (19,20,21,22), ISUB
   19 CALL POLE (PLHT2,POINT,TOTAL,ISAM,IMAX,PLHT1)
      GO TO 23
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   20 NSAW=NSAW+1
      CALL SAW (SAWV,POINT,TOTAL,ISAM,IMAX)
      GO TO 23
   21 NVENR=NVENR+1
      CALL VENR (VENRV,POINT,TOTAL,ISAM,IMAX)
      GO TO 23
   22 NSTUO=NSTUO+I
      CALL STUO (STUOV,POINT,TOTAL,ISAM,IMAX)
   23 CONTINUE
      CALL PULP (PULPV,POINT,TOTAL,ISAM,IMAX)
      LAST=2
   24 CONTINUE
   25 CONTINUE
C-----
C-----8EGIN ALL PROOUCT ROUTINES
C-----
      IF(JONREF.NE.3) GO TO 999
   26 JON=2
      REWIND 1
      ICARO=0
      IF (IBUG.EQ.I) WRITE (3,48) PROROT
      LAST=1
C-----
C-----READ AND EVALUATE OATA FOR SELECTEO PROOUCTS
C-----
      OO 38 KX=KMIN,KMAX,2
      LIM=KOUNT(KX)
      IF (LIM.CO.0) GO TO 3R
      OO 37 J=1,LIM
      OO 27 I=1,IO
   27 IND(I)=0
      READ(1)K,ISTRT,IOMY,OBH,IPLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,ILS,(((
     1KNOT(L,M,N),N=I,3),M=I,4),L=1,3),(124P(1),I=I,4),ITRHT,LEAN,IROT
      IF(ITRHT.LF.0) WRITE(3,471) ITRHT,IOMY
      IF(ITRHT.LE.0) GO TO 37
      CALL VOLUM (KCUVB,K8FV8,K8FV16,BAFV)
C-----
C-----IF RANOOM NUMBER GENERATOR(RANF(I)) IS NOT USEO TO OETERMINE SUB-
C-----SAMPLE FOR ROT REOUCTION,INSERT A GO TO 30 BRANCH CARO HERE. R=0
C-----
C     GO TO 30
      IF (RANF(1).LT.PROROT) 2B,29
   2B IROT=2
      GO TO 30
   29 IROT=0
   30 IF (IBUG.EO.0) GO TO 32
      ICARO=ICARO+1
      WRITE(3,49) ICARO,ISTRT,POINT(ISTRT),EF,K,OBH,IPLHT,ITRHT,ISWP,
     ILEAN,ICRK,IPCR,IFRK,IPFK,IFS,ILS,IROT,(124P(IM),IM=1,4)
      OO 31 L=1,3
      OO 31 M=1,4
   31 WMITE (3,SI) L,M,(KNOT(L,M,N),N=1,3)
   32 IF ((KX.EQ.KMAX).ANO.(J.EQ.LIM)) LAST=3
      IF (KPOLE.EQ.0) GO TO 33
      CALL POLE (PLHT2,POINT,TOTAL,ISAM,IMAX,PLHTI)
   33 IF (KSAW.EO.0) GO TO 34
      NSAW=0
      CALL SAW (SAWV,POINT,TOTAL,ISAM,IMAX)
   34 IF (KVENR.EO.0) GO TO 3S
      NVFNR=0
      CALL VENR (VENRV,POINT,TOTAL,ISAM,IMAX)
   35 IF (KSTUO.EO.0) GO TO 36
      NSTUO=0
      CALL STUO (STUOV,POINT,TOTAL,ISAM,IMAX)
   36 IF(KPULP.EO.0) GO TO 60
      CALL PULP (PULPV,POINT,TOTAL,ISAM,IMAX)
   60 IF(KUUT.EQ.0) GO TO 62
      IF(KP.EO.1) IPLHT=IPLHT*S
      WRITE(4) K,ISTRT,IOMY,OBH,IPLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,ILS,
     1(((KNOT(L,M,N),N=I,3),M=1,4),L=1,3),(124P(I),I=1,4),ITRHT,LEAN,
     2IROT,KP,TCFV,T8FV,EF,((8FSW(1,L),L=1,5),1=1,4),((8FVN(I,L),L=1,3),
     31=I,4),((BFST(1,L),L=1,3),I=1,4),(CFPL(I),1=1,2)
      NREC=NREC + 1
   62 LAST=2
   37 CONTINUE
   3B CONTINUE
      ENOFILE 4
      REWINO 4
      IF(KOUT.EO.0) GO TO 999
      WRITE(3,S3) NREC
      WRITE(3,S4) K,ISTRT,IOMY,OBH,IPLHT,ISWP,IPCR,ICRK,IPFK,IFRK,IFS,
     1ILS,(((KNOT(L,M,N),N=1,3),M=1,4),L=1,3),(124P(I),I=1,4),ITRHT,
     2LEAN,IROT,KP,TCFV,TBFV,FF,((BFSW(I,L),L=1,5),I=1,4),((BFVN(I,L),L=
     3I,3),I=1,4),((BFST(I,L),L=1,3),I=I,4),(CFPL(I),I=1,2)
      GO TO 999
   39 CALL EXIT
C-----
   40 FORMAT (8AIO)
   41 FORMAT (1HO*SAMPLE SIZE*I6,2X*LARGER THAN ALLOWABLE, SEE OATA STAT
     IEMENT*)
   42 FORMAT (2(S,F5.3,12I5,F5.0)
   43 FORMAT(9I5,2X,F8.4)
   44 FORMAT (16F5.0)
   45 FORMAT(2X12,I7,FS.2,1X12,IX7I1,IX12I1,2X12I1,2X12I1,2X4I1,IX12,
     11X2I1)
   46 FORMAT (1HO*OIAMETER*F6.2,2X*EXCEEOS MAXIMUM ALLOWABLE, OATA FROM
     1THIS THEE NOT USED*)
   47 FORMAT (IH *SAMPLE NUMBER*I6,2X*EXCEEOS MAXIMUM ALLOWABLE, OATA FR
     IOM THESE SAMPLES NOT USEO*)
  471 FORMAT(1H *TREE HEIGHT*I4,2X*EXCEEDS MINIMUM OR MAXIMUM FOR VOL CA
     ILCULATION, OATA FOR TREE IO*I8,* NOT USEO*)
   48 FORMAT (1H1,130(*=*)/1HO*TREF STATISTICS PIECE BY PIECE*F20.S,3X*O
     IF BUTT LUGS OISCAROEO BASEO ON ROT SAMPLF*/IHO,130(*=*))
   49 FORMAT(1H ,130(*=*)/IH *TREE NUMBER*I6,* SAMPLE NUMBER*IS,* SUBP
     ILOTS IN THIS CLUSTCR*FS.0,* VOL/ACRE EXPANSION FACTOR*F9.4/* TREE
     2 SIZE    OIAMETER CLASS*I3,* OIAMETFR*F6.2,* POLE HEIGHT*I3,* T
     3REE HEIGHT*13/* OFFECTS    SWEEP*12,* LEAN*12,* CROOK*I2,* CROO
     4K LOCATION*I2,* FORK*I2,* FORK LOCATION*I2,* FIRE SCAR*12,* LI
     SGHTNING SCAR*12,* ROT*I2/* CLEAR FACES IN FOURTH PIECF*412,/* KNO
     6TS PIECE     FACC    TOTAL     LIVE     OEAO*)
   SO FORMAT (1H ,I10,419)
   5I FORMAT (1H ,I10,4I9)
   53 FORMAT(1HO*  ENO-OF-RUN  TOTAL RECOROS OUTPUT ON TAPE 4 UNOER OPTI
     ION 2 =*I5,* LAST RECORO PROCESSEO WAS---*)
   54 FORMAT(1HO,I3,I4,I8,F6.2,I3,1x7I2,1X12I2,IX12I2,IX12I2,1X4I2,13,
     I2I2/1HO,1X(2,2FB.2,F3.4/IHO,2X,20F6.2/1HO,2x,20F6.2/1HO,2X,6F6.2)
      ENO
      SUBROUTINE POLE (PLHT2,POINT,TOTAL,ISAM,IMAX,PLHT1)
C-----
C-----ASSIGNS ACCEPTABLE POLES TO HEIGHT ANO OIAMETER CLASSES ANO
C-----ACCUMULATFS POLE OATA
C-----
      DIMENSION PLHT2(ISAM,15), POINT(ISAM), TOTAL(ISAM,4), PLHT1(1S,20)
C
      COMMON KNOT(3,4,3),I24P(4),(P(I1),INO(IO),KOUNT(SO),Y(1S),S(1S),
     IPROB(R),PCUVB(1I),PBFVR(10),PBFVI6(S),BFSW(4,5),RFVN(4,3),
     2BFST(4,3),CFPL(2),NPROO,KMIN,KMAX,NSAM,K,ISTRT,OBH,IPLHT,ISWP,
     3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUO,JON,
     4LAST,TCFV,T8FV,IBUG,ICARO,PRISM,KP,IOMY,KVOL,EF
C-----
      KP=0
      GO TO (1,4,4), LAST
    1 KMN=10
      IF (KMIN.GT.10) KMN=KMIN
      KMX=20
      IF (KMAX.LT.20) KMX=KMAX
      OO 3 I1=I,I5
      OO 2 KK=KMN,KMX,2
    2 PLHT1(II,KK)=0
      OO 3 JJ=I,NSAM
    3 PLHT2(JJ,II)=0
    4 IF (IPLHT.LE.0) GO TO 20
      IF (K.GT.20.OR.K.LT.IO) GO TO 20
      IFINK=((IPLHT/8.0)+0.9)
      IF(IFINK.GT.ITRHT) IFINK = ITRHT
C-----
C-----GRAOING SECTION
C-----
      ITOP=0
      ICUT=0
      GO TO (5,7), JON
    5 OO 6 L=I,IFINK
      IF(INO(L)) 6,6,20
    6 CONTINUE
C
    7 IF(ISWP) 8,8,20
    8 IF(ILS.GT.0.OR.IROT.GT.1) GO TO 20
      IF(LEAN.GE.2) GO TO 20
      IF(ICRK-1) 10,10,9
    9 IF(IPCR.GT.IFINK) GO TO 10
      IF(IPCR.NE.1.OR.IPCR.NE.IFINK) GO TO 20
      IF(IPCR.EO.I) ICUT=S
      IF(IPCR.EO.IFINK) ITOP=S
   IO IF(IFRK) 14,14,12
   12 IF(IPFK.GT.IFINK) GO TO 14
      IF(IPFK.NE.1.OR.IPFK.NE.IFINK) GO TO 20
      IF(IPFK.EO.1.ANO.ICUT.EQ.0) ICUT=5
      IF(IPFK.EO.IFINK.ANO.ITOP.EO.0) ITOP=S
   14 IF(IFS.GT.0.ANO.ICUT.EQ.0) ICUT=S
C
      LIM=AMINO(3,IFINK)
      OO 17 L=1,LIM
      OO 17 M=1,4
      IF (KNOT(L,M,2)-4) 16,20,20
   16 IF (KNOT(L,M,3)-4) 17,20,20
   17 CONTINUE
      IPLHT=IPLHT-ICUT-ITOP
      IFINK=((IPLHT/8.0)+0.9)
      IF(IFINK.GT.ITRHT) IFINK = ITRHT
      ZZ=CVOL(I.0,PRISM,EF)
C-----
C-----ADD INTO REGISTER
C-----
      IF(IBUG.EQ.I.ANO.LAST.NE.3) WRITE(3,28) ICARO,IPLHT,ZZ,K
      IPLHT=IPLHT/5
      IF (IPLHT.LT.2) GO TO 20
      KP=1
      PLHT1(IPLHT,K)=PLHT1(IPLHT,K)+ZZ/POINT(ISTRT)
      PLHT2(ISTRT,IPLHT)=PLHT2(ISTRT,IPLHT)+ZZ
      GO TO (18,20), JON
   18 OO 19 L=I,10
   19 INO(L)=1
   20 IF (LAST.NE.3) GO TO 27
      WRITE (3,29) (PROB(I),I=I,R)
      GO TO (21,22), JON
C-----
C-----PROOUCT PRIORITY HEADING
C-----
   21 WRITE (3,30)
      GO TO 23
C-----
C-----SINGLF PROOUCT HEADING
C-----
   22 WRITE (3,31)
   23 WRITE (3,32)
      OO 25 KK=KMN,KMX,2
      OO 24 II=2,15
   24 PLHT1(II,KK)=PLHT1(II,KK)/NSAM
      WRITE (3,33) KK,(PLHTI(11,KK),II=2,15)
   2S CONTINUE
      OO 26 II=2,15
   26 CALL STOER (NSAM,Y(11),S(II),PLHT2(I,II),POINT)
      WRITE (3,34) (Y(II),II=2,1S)
      WRITE (3,35) (S(II),II=2,1S)
   27 RETURN
C-----
   28 FORMAT (1H *TREE NUMBER*I6,12X,*ACCEPTEO AS POLE   CLASS*I3,2X,
     1 *WITH PER ACRE WEIGHT OF*F10.3,2X,*OIAMETER CLASS*I3)
   29 FORMAT (1H1,RA10)
   30 FORMAT (1HO,130I*=*)/1HO,*POLES BASEO ON PROOUCT PRIORITY CRITERIA
     1*)
   31 FORMAT (1HO,I30(*=*)/1HO,*POLES CONSIOEREO AS SINGLE PROOUCT*)
   32 FORMAT (1HO,130(*=*)/1HO*OIAMETER*37X*POLES PER ACRE BY HEIGHT CLA
     1SS*/IHO* CLASS*16X
     2*10*SX*1S*5X*20*5X*25*SX*30*SX*35*5X*40*SX*45*SX*SO*SX*5S*5X*60*
     3 SX*6S*SX*70*5X*75*/1HO,I30(*=*))
   33 FORMAT (1H 15,13X,14F7.2/IH )
   34 FORMAT (1HO,130(*=*)/1HO*HEIGHT CLASS SUM  *,14F7.2)
   35 FORMAT (1HO*STO ERR MFAN*6X,14F7.2/1HO,130(*=*))
      END
      SURROUTINE SAW (VCNT,POINT,TOTAL,ISAM,IMAX)
C
C GRAOES LOGS FOR SAWMILL MATERIAL USING A FIVE GRAOE SYSTEM
C ACCUMULATES SAWLOG OATA FOR 16FT LOG ANO HALF LOG
C
      OIMENSION VCNT(1SAM,4,IMAX),POINT(ISAM)
      OIMENSION TOTAL(ISAM,4)
C
      COMMON KNOT(3,4,3),I24P(4),1P(11),INO(10),KOUNT(SO),Y(1S),S(1S),
     IPROB(8),PCUVB(II),PBFV8(10),P8FV16(S),BFSW(4,5),8FVN(4,3),
     28FST(4,3),CFPL(2),NPROO,KMIN,KMAX,NSAM,K,ISTRT,O8H,IPLHT,ISWP,
     3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUO,JON,
     4LAST,TCFV,TBFV,IBUG,ICARO,PRISM,KP,IOMY,KVOL,EF
C
      GO TO (I,3,3),LAST
    I KMN=I2
      IF(KMIN.GT.I2) KMN=KMIN
      OO 2 KK=KMN,KMAX,2
      OO 2 J=1,4
      OO 2 I=I,NSAM
    2 VCNT(1,J,KK)=0.0
    3 IF(K.LT.I2) GO TO 200
      IF(NSAW-1)4,4,5
    4 OO 7 I=I,4
      OO 7 J=1,5
    7 BFSW(1,J)=0.0
```

```
C
C TEST FOR TWO OR MORE HALF LOGS IN TREE
C
    5 IF(ITRHT-2)200,6,6
    6 LOG=1
      LPCI=1
      LPC2=2
      IF(ITRHT.GT.2) GO TO 8
      KHT=0
      GO TO 10
    8 KHT=1
   10 GO TO (12,14,12),JON
   12 IF(INO(LPCI)+INO(LPC2)-1)I4,47,47
C
C GRAOE FIRST LOG (2 SECTIONS)
C
   14 NP=0
      OO 22 L=1,2
      NO=0
      N1=0
      OO 20 M=1,4
      IF(KNOT(L,M,1)-I)16,18,20
   I6 NO=NO + 2
      GO TO 20
   I8 NI=N1 + 1
   20 CONTINUE
      NP=NP+NO+N1
   22 CONTINUE
      IF(NP)26,26,24
   24 GO TO (26,26,26,26,28,28,28,28,28,28,28,30,30,30,32,32),NP
C
C IGR=4  OENOIES LOG GRADE 5
C
   26 IGR=4
      IRG=5
      GO TO 34
   28 IGR=3
      IRG=3
      GO TO 34
   30 IGR=2
      IRG=2
      GO TO 34
   32 IGR=1
      IRG=I
   34 GO TO (36,40,36),JON
   36 IF(NSAW-IGR)47,38,47
   38 1NO(LPC1)=1
      INO(LPC2)=I
   40 IF(KVOL-1) 903,903,900
C
C AOJUST GROSS LOG VOL FOR VISUAL OEFECTS FOR 16FT LOG
C
  900 PCNT=0.0
      IF(ILS.EQ.1) PCNT=PCNT + .25
      IF(ILS.EQ.2) PCNT=PCNT + .50
      1F(ISWP.EQ.2) PCNT=PCNT + .20
      IF(IFS.EQ.2.ANO.LPCI.EQ.1) PCNT=PCNT + .13
      IF(ICRK.GT.O.ANO.IPCR.EQ.LPC1.OR.IPCR.EQ.LPC2) PCNT=PCNT + .25
      IF(1FRK.GT.O.ANO.IPFK.EQ.LPC1.OR.IPFK.EQ.LPC2) PCNT=PCNT + .25
C
C AOO INTO REGISTERS
C
   41 IF(PCNT-1.) 42,44,44
   42 VLM=IP8FV16(LOG)-(P8FV16(LOG)*PCNT))
   43 VLM=CVOL(VLM,PR1SM,EF)
      GO TO 46
   44 VLM=0.0
      IF(LPCI.EQ.LPC2) GO TO 45
      IND(LPC1)=0
      INO(LPC2)=0
      GO TO 46
   45 1NO(LPCI)=0
   46 VCNT(ISTRT,IGR,K)=VCNT(1STRT,IGR,K) + VLM
      (F(IBUG.EQ.1.ANO.LAST.NE.3) GO TO 904
      GO TO 47
C
C NO GROSS LOG VOL AOJUSTMFNT FOR VISUAL OEFECTS 16FT LOG
C
  903 VLM=PBFVI6(LOG)
      8FSW(IGR,LOG)=8FSW(IGR,LOG) + VLM
      GO TO 43
C
  904 GO TO (906,908),KVOL
  908 WRITE(3,571) ICARO,LOG,IRG,VLM,K,PCNT
  571 FORMAT(1H *TREE NUM8ER*I6,2X*  LOG*I3,2X*ACCEPTEO AS SAWLOG GRAOE*
     1I3,2X*WITH AOJUSTEO WT VOL OF*F10.3,2X*OIAMETER CLASS*I3,2X*PRV =*
     2F5.2)
      GO TO 47
  906 WRITE(3,570) ICARO,LOG,1RG,VLM,K
  570 FORMAT(1H *TREE NUM8ER*16,2X*  LOG*13,2X*ACCEPTEO AS SAWLOG GRAOE*
     1I3,2X*WITH WE1GHTEO VOLUME OF*FI0.3,2X*OIAMETER CLASS*I3)
C
C TEST FOR SFCONO LOG
C
   47 CONTINUE
      GO TO (48,48,98,98,118,118,I26,126,200,200),LPC2
   48 1F(KHT)200,200,50
   50 IF((TRHT-4)52,82,82
C
C 1TRHT=3  NEXT SECTION IS HALF LOG (8FT)
C
   52 LOG=2
      LPC1=3
      LPC2=3
      KHT=0
      GO TO (54,56,54),JON
   54 IF((NO(LPC1))56,56,47
C
C GRAOE A HALF LOG SECTION (8FT)
C
   56 NO=0
      NI=0
      DO 62 M=I,4
      IF(KNOT(3,M,1)-1)58,60,62
   58 NO=NO + 2
      GO TO 62
   60 NI=NI + 1
   62 CONTINUE
      NP=NO+NI
      NP=NP*2
      IF(NP)66,66,64
   64 GO TO (66,66,66,66,68,68,68,68,68,68,68,70,70,70,72,72),NP
C
C IGR=4  OENOTES GRAOE 5
C
   66 1GR=4
      IRG=5
      GO TO 74
   68 IGR=3
      IRG=3
      GO TO 74
   70 IGR=2
      IRG=2
      GO TO 74
   72 IGR=1
      IRG=I
   74 GO TO (76,80,76),JON
   76 1F(NSAW-1GR)47,78,47
   78 1NO(LPC2)=1
   80 1F(KVOL-1)9I3,913,912
C
C AOJUST GROSS LOG VOL FOR VISUAL OEFECTS FOR 8FT LOG
C
  912 PCNT=0.0
      IF(1LS.EQ.I) PCNT=PCNT + .25
      IF(1LS.EQ.2) PCNT=PCNT + .50
      IF(1SWP.EQ.2) PCNT=PCNT + .20
      IF(ICRK.GT.O.ANO.1PCR.FQ.LPC1) PCNT=PCNT + .50
      1F(IFRK.GT.O.ANO.IPFK.EQ.LPC1) PCNT=PCNT + .50
      GO TO 4I
C
C NO GROSS LOG VOL AOJUSTMFNT FOR VISUAL OEFECTS 8FT LOG
C
  913 CONTINUE
      GO TO 903
C
C ITRHT=4  NEXT SECTION IS FULL LOG (16FT)
C
   82 LOG=2
      LPCI=3
      LPC2=4
      1F(1TRHT.GT.4) GO TO 8I
      KHT=0
      GO TO 83
   81 KHT=1
   83 GO TO (84,86,84),JON
   84 IF(1NO(LPCI)+INO(LPC2)-1)86,47,47
C
C GRAOE SECONO LOG (16FT)
C
   86 NO=0
      N1=0
      N2=0
      00 92 M=1,4
      IF(KNOT(3,M,1)-1)88,90,92
   88 NO=NO + 2
      GO TO 92
   90 N1=N1 + 1
   92 CONTINUE
      00 96 M=I,4
      1F(I24P(M))94,94,96
   94 N2=N2 + 2
   96 CONTINUE
      NP=NO+N1+N2
      1F(NP)26,26,24
C
C TEST FOR SECTIONS A8OVE TWO LOGS
C
   98 IF(KHT)200,200,100
  100 IF(ITRHT-6)102,108,I08
  102 LOG=3
      LPCI=5
      LPC2=5
  I03 KHT=0
      GO TO I104,106,104),JON
  104 IF(INO(LPC1))106,106,47
  I06 IGR=4
      IRG=5
      GO TO 74
  I08 LOG=3
      LPCI=5
      LPC2=6
      IF(ITRHT.GT.6) GO TO I10
  109 KHT=0
      GO TO I12
  110 KHT=1
  112 GO TO I114,I16,1I4),JON
  I14 IF(INO(LPC1)+INO(LPC2)-1)116,47,47
  116 1GR=4
      1RG=5
      GO TO 34
C
  I18 IF(KHT)200,200,120
  120 1F(ITRHT-8)122,124,124
  122 LOG=4
      LPCI=7
      LPC2=7
      GO TO I03
  124 LOG=4
      LPC1=7
      LPC2=8
      IF(ITRHT.GT.8) GO TO 1I0
      GO TO 109
C
  126 IF(KHT)200,200,128
  128 IF(1TRHT-10)130,I32,132
  I30 LOG=5
      LPCI=9
      LPC2=9
      GO TO 103
  I32 LOG=5
      LPC1=9
      LPC2=I0
      GO TO 109
C
  200 1F(LAST.NE.3) GO TO 500
      WR1TE(3,580) (PROB(I),I=1,8)
      GO TO (204,202),JON
C
C SINGLE PROOUCT HEAOINGS
C
  202 GO TO (914,916),KVOL
  914 WRITE(3,586)
      GO TO 918
  916 WR1TEI3,588)
  9I8 WR1TE(3,590)
      GO TO 212
  204 IF(NSAW-4)206,208,206
  206 NSWW=NSAW
      GO TO 210
  208 NSWW=5
C
C PROOUCT PRIOR1TY HEAO1NGS
C
  2I0 GO TO (920,922),KVOL
  920 WRITE(3,596) NSWW
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      GO TU 924
  922 WRITE(3,598) NSWW
  924 WRITE(3,600)
  212 00 214 I=1,NSAM
      00 214 J=1,4
  214 TOTAL(I,J)=0.0
      00 226 KK=KMN,KMAX,2
      00 216 J=1,4
  216 CALL STOER (NSAM,Y(J),S(J),VCNT(1,J,KK),POINT)
      GO TO (220,218),JON
  218 WRITE(3,610) KK,(Y(I),I=1,4)
C
C SINGLE PRODUCT OUTPUT
C
      WRITE(3,620) (S(I),I=1,4)
      GO TO 222
C
C PROOUCT PRIORITY OUTPUT
C
  220 WRITE(3,630) KK,Y(NSAW)
      WRITE(3,640) S(NSAW)
  222 DO 224 J=1,4
      DO 224 I=1,NSAM
  224 TOTAL(I,J)=TOTAL(I,J)+VCNT(I,J,KK)
  226 CONTINUE
      00 228 J=1,4
  228 CALL STOER (NSAM,Y(J),S(J),TOTAL(1,J),POINT)
      GO TO (232,230),JON
  230 WRITE(3,650) (Y(I),I=1,4)
      WRITE(3,660) (S(I),(=1,4)
      GO TO 500
  232 WRITE(3,670) Y(NSAW)
      WRITE(3,680) S(NSAW)
  500 RETURN
C
  580 FORMAT (1H1,8A10)
  586 FORMAT(1HO,130(*=*)/1HO*SAWLOGS CONSIOEREO AS SINGLE PROOUCT   GRO
     1SS VOLUME NOT AOJUSTEO FOR VISUAL OEFECTS*)
  588 FORMAT(1HO,130(*=*)/1HO*SAWLOGS CONSIOEREO AS SINGLE PROOUCT   GRO
     1SS VOLUME AOJUSTEO FOR VISUAL OEFECTS*)
  590 FORMAT(1HO,130(*=*)/1HO*DIAMETER*32X*BOARO FOOT VOLUMES PER ACRE B
     1Y GRAOE*/1HO* CLASS*25X*1*17X*2*17X*3*17X*5*/1HO,130(*=*))
  596 FORMAT(1HO,130(*=*)/1HO*GRAOE*I3,* SAWLOG VOLUMES BASEO ON PROOUCT
     1 PRIORITY CRITERIA  GROSS VOLUME NOT AOJUSTEO FOR VISUAL OEFECTS*)
  598 FORMAT(1HO,130(*=*)/1HO*GRAOE*I3,* SAWLOG VOLUMES BASEO ON PROOUCT
     1 PRIORITY CRITERIA  GROSS VOLUME AOJUSTEO FOR VISUAL OEFECTS*)
  600 FORMAT(1HO,130(*=*)/1HO*OIAMETER*17X*BOARO FOOT VOLUMES PER ACRE *
     I/1H * CLASS*/1HO,130(*=*))
  610 FORMAT (1HO,I4,6X,*MEAN*F20.2,3(F18.2))
  620 FORMAT (1H ,10X*STO ERR*F17.2,3(F18.2))
  630 FORMAT (1HO,I4,24X*MEAN*F20.2)
  640 FORMAT (1H ,28X*STO ERR*F17.2)
  650 FORMAT (1HO,130(*=*)/1HO*TOTAL  MEAN*3X,F20.2,3(F18.2))
  660 FORMAT (1HO*STD ERR MEAN*2X,F20.2,3(F18.2)/1HO,130(*=*))
  670 FORMAT (1HO,130(*=*)/1HO*TOTAL*23X*MEAN*F20.2)
  680 FORMAT (1HO,28X*STO ERR*F17.2/1HO,130(*=*))
      ENO
      SUBROUTINE VENR (VCNT,POINT,TOTAL,ISAM,IMAX)
C-----
C-----GRAOES FOR VENEER POTENTIAL USING A THREE GRAOE SYSTEM
C-----ACCUMULATES VENEER VOLUMES
C-----
      OIMENSION VCNT(ISAM,4,IMAX),POINT(ISAM),TOTAL(ISAM,4)
C
      COMMON KNOT(3,4,3),I24P(4),IP(11),INO(10),KOUNT(50),Y(15),S(15),
     1PROB(8),PCUV8(11),P8FV8(10),P8FV16(5),8FSW(4,5),8FVN(4,3),
     28FST(4,3),CFPL(2),NPROD,KMIN,KMAX,NSAM,K,ISTRT,OBH,IPLHT,ISWP,
     3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUO,JON,
     4LAST,TCFV,T8FV,IBUG,ICARO,PRISM,KP,IOMY,KVOL,EF
C-----
      GO TO (1,3,3), LAST
    1 KMN=10
      IF (KMIN.GT.10) KMN=KMIN
      00 2 KK=KMN,KMAX,2
      00 2 J=1,4
      00 2 I=1,NSAM
    2 VCNT(I,J,KK)=0.0
    3 IF (K.LE.10) GO TO 21
      IF (K-14) 4,5,6
    4 LIM=1
      GO TO 7
    5 LIM=2
      GO TO 7
    6 LIM=3
    7 LIM=AMINO(LIM,ITRHT)
      IF(NVENR-1)8,8,10
    8 00 9 I=1,4
      00 9 J=1,3
    9 OFVN(I,J)=0.0
   10 00 20 L=1,LIM
      GO TO (50,52),JON
   50 IF(INO(L))52,52,20
C-----
C-----GRAOING SECTION
C-----
   52 IGR=1
      00 54 M=1,4
      IF(KNOT(L,M,3).GT.0.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,2)
      IF(KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,3)
      IF(KNOT(L,M,3).GT.3) IGR=4
      IF(KNOT(L,M,3).GT.3) GO TO 55
   54 CONTINUE
      IF(K.LT.16) IGR=AMAXO(IGR,2)
   55 CONTINUE
      GO TO (56,60),JON
   56 IF(NVENR-IGR)20,58,20
   58 INO(L)=I
   60 IF(KVOL-1)102,102,100
C-----
C-----AOJUST GROSS LOG VOL FOR VISUAL OEFECTS
C-----
  100 PCNT=0.0
      IF(IROT.GT.1.ANO.L.EO.1) PCNT=PCNT + 1.0
      (F(ICRK)64,64,62
   62 (F(ICRK.GE.2.ANO.L.EO.IPCR) PCNT=PCNT + 1.0
      IF(ICRK.EO.1.ANO.L.EO.IPCR) PCNT=PCNT + .5
   64 IF(IFRK.GT.O.ANO.L.EQ.IPFK) PCNT=PCNT + .5
      (F(ILS)68,68,66
   66 IF(ILS.GE.2) PCNT=PCNT + .5
      IF(ILS.EO.1) PCNT=PCNT + .25
   68 IF(IFS.GE.2.ANO.L.FO.1) PCNT=PCNT + .25
C-----
C-----ADD INTO REGISTERS
C-----
      IF(PCNT-1.)70,72,72
   70 VLM=(P8FV8(L)-(P8FV8(L)*PCNT))
   71 VLM=CVOL(VLH,PRISM,EF)
      GO TO 74
   72 VLM=0.0
      INO(L)=0
   74 VCNT(ISTRT,IGR,K)=VCNT(ISTRT,IGR.K) + VLM
      (F(IBUG.EO.1.AND.LAST.NE.3) GO TU 104
      GO TO 20
C
C NO GROSS LOG VOI  AOJUSTMENT FOR VISUAL OEFECTS
C
C 102 IF(IROT.GT.1.AND.L.EQ.1) GO TO 99
C     (F(ICRK.GT.1.ANO.L.EO.IPCR) GO TO 99
C     IF(IFRK.GT.O.ANO.L.EO.IPFK) GO TO 99
C     IF(ILS.GT.0) GO TO 99
C     (F(IFS.GE.2.ANO.L.EO.1) GO TO 99
  102 VLM=P8FV8(L)
      8FVN(IGR,L)=8FVN(IGR,L) + VLM
      GO TO 71
C
C SET INO SELECTOR OFF  PIECE FAILEO VISUAL OEFECTS TEST
C
C     INO(L)=0
C     GO TO 20
C
  104 GO TO (108,106),KVOL
  106 WRITE(3,361) ICARO,L,IGR,VLM,K,PCNT
      GO TU 20
  108 WRITE(3,36) ICARO,L,IGR,VLM,K
   20 CONTINUE
   21 IF (LAST.NE.3) GO TO 35
      WRITE (3,37) (PROB(I),I=1,8)
      GO TO (23,22), JON
C-----
C-----SINGLE PROOUCT HEAOING
C-----
   22 GO TO (110,112),KVOL
  110 WRITE(3,376)
      GO TO 114
  112 WRITE(3,378)
  114 WRITE(3,38)
      GO TO 24
C-----
C-----PROOUCT PRIORITY HEAOING
C-----
   23 GO TO (116,118),KVOL
  116 WRITE(3,386) NVENR
      GO TO 120
  118 WRITE(3,388) NVENR
  120 WRITE(3,39)
   24 00 25 J=1,4
      00 25 I=1,NSAM
   25 TOTAL(1,J)=0.0
      00 31 KK=KMN,KMAX,2
      00 26 J=1,4
   26 CALL STOER (NSAM,Y(J),S(J),VCNT(1,J,KK),POINT)
      GO TO (28,27), JON
C-----
C-----SINGLE PROOUCT OUTPUT
C-----
   27 WRITE (3,40) KK,(Y(I),I=1,4)
      WRITE (3,41) (S(I),I=1,4)
      GO TO 29
C-----
C-----PROOUCT PRIORITY OUTPUT
C-----
   28 WRITE (3,42) KK,Y(NVENR)
      WRITE (3,43) S(NVENR)
   29 00 30 J=1,4
      00 30 I=1,NSAH
   30 TOTAL(1,J)=TOTAL(I,J)+VCNT(I,J,KK)
   31 CONTINUE
      00 32 J=1,4
   32 CALL STOER (NSAM,Y(J),S(J),TOTAL(1,J),POINT)
      GO TO (34,33), JON
   33 WRITE (3,44) (Y(I),I=1,4)
      WRITE (3,45) (S(I),I=1,4)
      GO TO 35
   34 WRITE (3,46) Y(NVENR)
      WRITE (3,47) S(NVENR)
   35 RETURN
C-----
   36 FORMAT (1H *TREE NUMBER*16,2X*PIECE*I3,2X*ACCEPTEO AS VENEER GRAOE
     1*I3,2X*WITH WEIGHTEO VOLUME OF*F10.3,2X*OIAHETER CLASS*I3)
  361 FORHAT(1H *TREE NUMBER*I6,2X*PIECE*13,2X*ACCEPTEO AS VENEER GRAOE*
     1I3,2X*WITH AOJUSTEO WT VOL OF*F10.3,2X*OIAMETER CLASS*I3,2X*PRV =*
     2F5.2)
   37 FORMAT (1H1,8A10)
  376 FORMAT(1HO,130(*=*)/1HO*VENEER CONSIOEREO AS A SINGLE PROOUCT  GRO
     1SS VOLUHE NOT AOJUSTEO FOR VISUAL OEFECTS*)
  378 FORMAT(1HO,130(*=*)/1HO*VENEER CONSIOEREO AS A SINGLE PROOUCT  GRO
     1SS VOLUME AOJUSTEO FOR VISUAL OEFECTS*)
   38 FORMAT(1HO,130(*=*)/1HO*OIAMETER*23X*BOARO FOOT VOLUMES PER ACRE B
     1Y GRAOE*/1HO* CLASS*25X*1*17X*2*17X*3*17X*4*/1HO,130(*=*))
  386 FORHAT(1HO,130(*=*)/1HO*GRAOE*I3,* VENEER BASEO ON PROOUCT PRIORIT
     1Y CRITERIA  GROSS VOLUME NOT ADJUSTEO FOR VISUAL OEFECTS*)
  388 FORMAT(1HO,130(*=*)/1HO*GRAOE*I3,* VENEER BASEO ON PROOUCT PRIORIT
     1Y CRITERIA  GROSS VOLUME AOJUSTEO FOR VISUAL OEFECTS*)
   39 FORHAT(1HO,130(*=*)/1HO*OIAHETER*I7X*BOARO FOOT VOLUME PER ACRE *
     1/1H * CLASS*/1HO,130(*=*))
   40 FORMAT (1HO,I4,6X*HEAN*F20.2,3(F18.2))
   41 FORMAT (1H ,10X*STO ERR*F17.2,3(F18.2))
   42 FORMAT (1HO,I4,24X*HEAN*F20.2)
   43 FORMAT (IH ,28X*STO ERR*F17.2)
   44 FORHAT (1HO,130(*=*)/1HO,*TOTAL  MEAN*3X,F20.2,3(F18.2))
   45 FORMAT (1HO*STO ERR MEAN*2X,F20.2,3(F18.2)/1HO,130(*=*))
   46 FORMAT (1HO,130(*=*)/IHO*TOTAL*23X*HEAN*F20.2)
   47 FORMAT (1HO,28X*STO ERR*F17.2/1HO,130(*=*))
      ENO
      SUBROUTINE STUO (VCNT,POINT,TOTAL,ISAM,IMAX)
C-----
C-----GRAOES FOR STUO POTENTIAL USING A THREE GRAOE SYSTEM
C-----ACCUHULATES STUO VOLUMES
C-----
      OIMENSION VCNT(ISAM,4,9),POINT(ISAM),TOTAL(ISAM,4)
C
      COMMON KNOT(3,4,3),I24P(4),IP(11),INO(10),KOUNT(50),Y(15),S(15),
     1PROB(8),PCUV8(11),P8FV8(I0),P8FV16(5),8FSW(4,5),8FVN(4,3),
     28FST(4,3),CFPL(2),NPROD,KMIN,KMAX,NSAM,K,ISTRT,OBH,IPLHT,ISWP,
     3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUO,JON,
     4LAST,TCFV,TBFV,IBUG,ICARO,PRISM,KP,IOMY,KVOL,EF
C-----
      GO TO (1,3,3), LAST
    1 KMN=6
      IF (KMIN.GT.6) KHN=KMIN
      KMX=22
      IF (KMAX.LT.22) KMX=KMAX
      00 2 KK=1,9
      00 2 J=1,4
      DO 2 I=1,NSAM
    2 VCNT(I,J,KK)=0.0
```

```
      KMN=(KMN-4)/2
      KMX=(KMX-4)/2
    3 IF (K.LT.6) GO TO 22
      KK=(K-4)/2
      IF (K-22) 5,4,22
    4 LIM=3
      GO TU 12
    5 IF (K-20) 7,6,6
    6 LIM=2
      GO TO 12
    7 LIM=I
   12 LHT=AMINO(ITRHT,3)
      IF (LIM.GT.LHT) GO TO 22
      IF(NSTUO-1)8,8,10
    8 OO 9 I=1,4
      OO 9 J=1,3
    9 8FST(I,J)=0.0
   10 OO 2I L=LIM,LHT
      GO TO (50,52),JON
   50 IF(INO(L))52,52,21
   52 NI=0
C-----
C-----GRAOING SECTION
C-----
      IGR=1
      OO 54 M=I,4
      NI=N1+KNOT(L,M,1)
      IF(KNOT(L,M,3).GT.I.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,2)
      IF(KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,3)
      IF(KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.3) IGR=4
      IF(KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.3) GO TO 55
   54 CONTINUE
      IF(N1.GT.16) IGR=AMAXO(IGR,2)
      IF(N1.GT.32) IGR=AMAXO(IGR,3)
   55 CONTINUE
      GO TO (56,60),JON
   56 IF(NSTUO-IGR)21,5B,21
   58 INO(L)=I
   60 IF(KVOL-1)102,I02,100
C-----
C-----AOJUST GROSS LOG VOL FOR VISUAL OEFECTS
C-----
  100 PCNT=0.0
      IF(IROT.GT.1.ANO.L.EQ.I) PCNT=PCNT + 1.0
      IF(ICRK)64,64,62
   62 IF(ICRK.GE.2.ANO.L.EQ.IPCR) PCNT=PCNT + I.0
      IF(ICRK.EQ.1.ANO.L.EQ.IPCR) PCNT=PCNT + .5
   64 IF(IFRK.GT.0.ANO.L.EQ.IPFK) PCNT=PCNT + .5
      IF(ILS)68,68,66
   66 IF(ILS.GE.2) PCNT=PCNT + .5
      IF(ILS.EQ.1) PCNT=PCNT + .25
   6B IF(IFS.GE.2.ANO.L.EQ.1) PCNT=PCNT + .25
C-----
C-----AOO INTO REGISTERS
C-----
      IF(PCNT-1.)70,72,72
   70 VLM=(P8FV8(L)-(P8FV8(L)*PCNT))
   71 VLM=CVOL(VLM,PRISM,EF)
      GO TO 74
   72 VLM=0.0
      INO(L)=0
   74 VCNT(ISTRT,IGR,KK)=VCNT(ISTRT,IGR,KK) + VLM
      IF(I8UG.EQ.1.ANO.LAST.NE.3) GO TO 104
      GO TO 2I
C
C NO GROSS LOG VOL AOJUSTMENT FOR VISUAL OEFECTS
C
C 102 IF(IROT.GT.1.ANO.L.EQ.1) GO TO 99
C     IF(ICRK.GT.1.ANO.L.EQ.1PCR) GO TO 99
C     IF(IFRK.GT.0.ANO.L.EQ.IPFK) GO TO 99
C     IF(ILS.GT.0) GO TO 99
C     IF(IFS.GE.2.ANO.L.EQ.1) GO TO 99
  I02 VLM=PBFV8(L)
      BFST(IGR,L)=BFST(IGR,L) + VLM
      GO TO 71
C
C SET INO SELECTOR OFF  PIECE FAILEO VISUAL OEFECTS TEST
C
C  99 INO(L)=0
C     GO TO 21
C
  104 GO TO (I08,I06),KVOL
  I06 WRITE(3,37I) ICARO,L,IGR,VLM,K,PCNT
      GO TO 21
  10B WRITE(3,37) ICARO,L,IGR,VLM,K
   21 CONTINUE
   22 IF (LAST.NE.3) GO TO 36
      WRITE (3,3B) (PROB(I),I=I,8)
      GO TO (24,23), JON
C-----
C-----SINGLE PROOUCT HEAOING
C-----
   23 GO TO (110,112),KVOL
  110 WRITE(3,386)
      GO TO 114
  112 WRITE(3,3B8)
  1I4 WRITE(3,39)
      GO TO 25
C-----
C-----PROOUCT PRIORITY HEAOING
C-----
   24 GO TO (116,118),KVOL
  116 WRITE(3,396) NSTUO
      GO TO 120
  118 WRITE(3,39B) NSTUO
  120 WRITE(3,40)
   25 DO 26 J=1,4
      OO 26 I=1,NSAM
   26 TOTAL(1,J)=0.0
      OO 32 KK=KMN,KMX
      KX=KK*2+4
      DO 27 J=I,4
   27 CALL STOER (NSAM,Y(J),S(J),VCNT(1,J,KK),POINT)
      GO TO (29,2B), JON
C-----
C-----SINGLE PROOUCT OUTPUT
C-----
   28 WRITE (3,41) KX,(Y(I),I=I,4)
      WRITE (3,42) (S(I),I=1,4)
      GO TO 30
C-----
C-----PROOUCT PRIORITY OUTPUT
C-----
   29 WRITE (3,43) KX,Y(NSTUO)
      WRITE (3,44) S(NSTUO)
   30 OO 31 J=1,4
      OO 31 I=I,NSAM
   31 TOTAL(I,J)=TOTAL(1,J)+VCNT(I,J,KK)
   32 CONTINUE
      OO 33 J=1,4
   33 CALL STOER (NSAM,Y(J),S(J),TOTAL(I,J),POINT)
      GO TO (35,34), JON
   34 WRITE (3,45) (Y(I),I=1,4)
      WRITE (3,46) (S(I),I=1,4)
      GO TO 36
   35 WRITE (3,47) Y(NSTUO)
      WRITE (3,48) S(NSTUO)
   36 RETURN
C-----
   37 FORMAT (IH *TREE NUM8ER*I6,2X*PIECE*I3,2X*ACCEPTEO AS STUO   GRAOE
     1*I3,2X*WITH WEIGHTEO VOLUME OF*FIO.3,2X*OIAMETER CLASS*I3)
  37I FORMAT(1H *TREE NUM8ER*I6,2X*PIECE*I3,2X*ACCEPTEO AS STUO   GRAOE*
     1I3,2X*WITH AOJUSTEO WT VOL OF*FIO.3,2X*OIAMETER CLASS*I3,2X*PRV =*
     2F5.2)
   38 FORMAT (1HI,8A10)
  3B6 FORMAT(1HO,I30(*=*)/1HO*STUOS CONSIOEREO AS SINGLE PROOUCT  GROSS
     1VOLUME NOT AOJUSTEO FOR VISUAL OEFECTS*)
  388 FORMAT(1HO,130(*=*)/IHO*STUOS CONSIOEREO AS SINGLE PROOUCT  GROSS
     1VOLUME AOJUSTEO FOR VISUAL OEFECTS*)
   39 FORMAT(IHO,130(*=*)/IHO*OIAMETER*23X*BOARO FOOT VOLUMES PER ACRE B
     IY GRAOE*/1HO* CLASS*25X*1*17X*2*17X*3*17X*4*/1HO,130(*=*))
  396 FORMAT(1HO,I30(*=*)/IHO*GRAOE*I3,* STUOS BASEO ON PROOUCT PRIORITY
     I CRITERIA  GROSS VOLUME NOT AOJUSTEO FOR VISUAL OEFECTS*)
  398 FORMAT(IHO,130(*=*)/1HO*GRAOE*I3,* STUOS 8ASEO ON PROOUCT PRIORITY
     1 CRITERIA  GROSS VOLUME AOJUSTEO FOR VISUAL OEFECTS*)
   40 FORMAT(IHO,130(*=*)/1HO*OIAMETER*17X*BOARO FOOT VOLUME PER ACRE *
     1/IH * CLASS*/1HO,I30(*=*))
   41 FORMAT (1HO,I4,6X*MEAN*F20.2,3(FI8.2))
   42 FORMAT (1H ,IOX*STO ERP*FI7.2,3(F1B.2))
   43 FORMAT (IHO,I4,24X*MEAN*F20.2)
   44 FORMAT (1H ,28X*STO ERR*F17.2)
   45 FORMAT (1HO,I30(*=*)/1HO*TOTAL*2X*MEAN*,3X,F20.2,3(F18.2))
   46 FORMAT (1HO*STO ERR MEAN*2X,F20.2,3(F18.2)/1HO,130(*=*))
   47 FORMAT (1HO,130(*=*)/1HO*TOTAL*23X*MEAN*F20.2)
   48 FORMAT (1HO,2BX*STO ERR*F17.2/1HO,130(*=*))
      ENO
      SUBROUTINE PULP (PULPV,POINT,TOTAL,ISAM,IMAX)
C-----
C-----ACCUMULATES CU8IC FOOT VOLUME FOR PIECES NOT USEO AS OTHER PROOUCT
C-----
      OIMENSION PULPV(ISAM),POINT(ISAM),TOTAL(ISAM,4)
C
      COMMON KNOT(3,4,3),I24P(4),IP(11),INO(10),KOUNT(50),Y(15),S(I5),
     IPRO8(B),PCUVB(I1),PBFVR(10),PBFV16(5),BFSW(4,5),BFVN(4,3),
     2BFST(4,3),CFPL(2),NPROD,KMIN,KMAX,NSAM,K,ISTRT,OBH,IPLHT,ISWP,
     31PCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUO,JON,
     4LAST,TCFV,TBFV,I8UG,ICARO,PRISM,KP,IOMY,KVOL,EF
C-----
      GO TO (I,20,20),LAST
    1 OO I5 I=1,NSAM
   I5 PULPV(I)=0.0
   20 NT=0
      KTOP=ITRHT + I
      OO 25 I=1,2
   25 CFPL(I)=0.0
      OO 30 I=I,ITRHT
   30 NT=NT + INO(I)
      IF(NT)35,35,85
C-----
C-----TREE EXCLUOEO FROM PRIOR PROOUCT CONSIOERATION
C-----MAKE GROSS VOLUME AOJUSTMENTS FOR VISUAL OEFECTS
C-----
   35 IF(KVOL-I)60,60,37
   37 OO 50 I=1,ITRHT
      PCNT=0.0
      IF(ILS)42,42,40
   40 PCNT=PCNT + I.0
   42 IF(IFS.GT.O.ANO.I.EQ.I) PCNT=PCNT + .5
      IF(PCNT-1.)44,46,46
   44 VLM=(PCUVB(I)-(PCUV8(I)*PCNT))
      GO TO 48
   46 VLM=0.0
   48 VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF(IBUG.EQ.I.ANO.LAST.NE.3) WRITE(3,101) 1CARO,I,VLM,K,PCNT
   50 CONTINUE
C-----
C-----OO TOP PIECE FOR AOJUSTEO GROSS VOLUME
C-----
   51 IF(ILS)52,52,54
   52 VLM=PCUVB(KTOPI
      PCNT=0.0
      GO TO 56
   54 VLM=0.0
      PCNT=1.0
   56 VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRTI + VLM
      IF(IBUG.EQ.I.ANO.LAST.NE.3) WRITE(3,103) ICARO,VLM,K,PCNT
   58 IF(LAST.NE.3) GO TO 900

C
C-----OO TREE FOR GROSS VOLUMES--NO AOJUSTMENT FOR VISUAL OEFECTS
C
   60 OO 62 I=I,ITRHT
      VLM=PCUV8(I)
      CFPL(2)=CFPL(2) + VLM
      VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF(I8UG.EQ.I.ANO.LAST.NE.3) WRITE(3,10) ICARO,I,VLM,K
   62 CONTINUE
C
C-----OO TOP PIECE FOR GROSS VOLUME--NO AOJUSTMENT FOR VISUAL OEFECTS
C
   64 VLM=PCUVB(KTOP)
      CFPL(1)=CFPL(1) + VLM
      VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF(IBUG.EQ.1.ANO.LAST.NE.3) WRITE(3,9) ICARO,VLM,K
      GO TO 5B
C-----
C-----STEM SECTIONS EXCLUOEO FROM PRIOR PROOUCT CONSIOERATION PLUS TOP
C-----MAKE GROSS VOLUME AOJUSTMENTS FOR VISUAL OEFECTS
C-----
   B5 IF(KVOL-1)98,98,87
   B7 OO 96 I=1,ITRHT
      IF(INO(I).EQ.I) GO TO 96
      IF(ILS)90,90,92
   90 VLM=PCUV8(I)
      PCNT=0.0
      GO TO 94
   92 VLM=0.0
      PCNT=1.0
   94 VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF(IBUG.EQ.I.ANO.LAST.NE.3) WRITE(3,I01) 1CARO,I,VLM,K,PCNT
   96 CONTINUE
```

```
      GO TO 51
C
C-----DD STEM FOR GROSS VOLUMES--NO AOJUSTMENT FOR VISUAL OEFECTS
C
   98 OO 100 I=1,ITRHT
      IF(INO(I).EQ.1) GO TD 100
      VLM=PCUV8(I)
      CFPL(2)=CFPL(2) + VLM
      VLM=CVOL(VLH,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLH
      IF(I8UG.EO.1.AND.LAST.NE.3) WRITE(3,10) ICARO,I,VLH,K
  1DD CONTINUE
      GO TO 64
  110 WRITE(3,11) (PRO8(I),I=1,8)
      GO TO (6,5), JDN
C-----
C-----ALL PROOUCTS HFAOING
C-----
    5 GO TO (102,1D4),KVDL
  102 WRITE(3,12)
      GO TO 7
  1D4 WRITE(3,121)
      GO TO 7
C
    6 GO TO (1D6,108),KVOL
  1D6 WRITE(3,13)
      GO TO 7
  108 WRITE(3,131)
C
    7 OO 8 I=1,NSAM
    8 TOTAL(I,1)=0.D
      CALL STOER (NSAH,Y(1),S(1),PULPV(1),POINT)
      WRITE (3,14) Y(1),S(1)
  9DO RETURN
C-----
C-----
    9 FORMAT(1H *TREE NUMBER*I6,2X*TOP PIECE*,1X*ACCEPTEO AS PULP*I3X*WI
     1TH WEIGHTEO VOLUME OF*F1D.3,2X*OIAMETER CLASS*I3)
   1D FORMAT (1H *TREE NUHBER*I6,2X*PIECE*I3,2X*ACCEPTED AS PULP*I3X*WIT
     1H WEIGHTEO VOLUME OF*F10.3,2X*DIAHETER CLASS*I3)
  101 FORMAT(1H *TREE NUMBER*I6,2X*PIECE*I3,2X*ACCEPTEO AS PULP*I3X*WITH
     1 AOJUSTEO WT VOL OF*F1D.3,2X*OIAMETER CLASS*I3,2X*PRV =*F5.2)
  103 FORMAT(1H *TREE NUMBER*I6,2X*TOP PIECE*,1X*ACCEPTED AS PULP*I3X*WI
     1TH AOJUSTEO WT VOL OF*F10.3,2X*DIAMETER CLASS*I3,2X*PRV =*F5.2)
   11 FORMAT (1H1,8A10)
   12 FORHAT(1HO,13D(*=*)/1HO*PULP CONSIDEREO AS SINGLE PROOUCT  GROSS V
     1OLUME NOT AOJUSTEO FOR VISUAL OEFECTS*/1HO,I30(*=*))
  121 FORMAT(1HO,13D(*=*)/1HO*PULP CONSIOFREO AS SINGLE PRDOUCT  GROSS V
     1DLUME AOJUSTED FOR VISUAL OEFECTS*/1HD,130(*=*))
   13 FORMAT(1HO,130(*=*)/1HO*PULP CONSIOERED AS RESIOUAL PRODUCT ONLY
     1GROSS VOLUME NOT AOJUSTED FOR VISUAL DEFFCTS*/1HD,130(*=*))
  131 FORMAT(1HO,13D(*=*)/1HO*PULP CONSIOERED AS RESIOUAL PROOUCT ONLY
     1GROSS VOLUME ADJUSTEO FDR VISUAL OEFECTS*/1HD,130(*=*))
   14 FORMAT (1H *TOTAL PULP VOLUHE IN CUBIC FEET*F18.2/1HO*STANOARO ERR
     1OR*F35.2/1HD,13D(*=*))
      ENO

      SUBRDUTINE VOLUH (KCUV8,K8FV8,K8FV16,8AFV)
C
C THIS ROUTINE CALCULATES GROSS CUFT ANO 8RFT TREE VOL USING HGT IN 16FT
C LOGS ANO O8H ANO ALSO CALCULATES A VOL./ACRE EXPANSION FACTOR FDR EACH
C SAMPLE TREE USING O8H ANO THE INPUT 8AF VALUE OF THE ANGLE GAUGE USEO.
C THE CALCULATEO GROSS VOLUHES ARE ALLOCATEO AMONG STEM SECTIONS OF THF
C TREE 8Y SELECTEO PERCENTAGE TA8LES.
C
      OIMENSION KCUVR(65),K8FV8(55),K8FV16(29)
C
      COMMON KNOT(3,4,3),I24P(4),IP(11),IND(10),KOUNT(50),Y(15),S(15),
     1PRO8(8),PCUV8(11),P8FV8(1D),P8FV16(5),8FSW(4,5),8FVN(4,3),
     28FST(4,3),CFPL(2),NPROO,KHIN,KHAX,NSAM,K,ISTRT,O8H,IPLHT,ISWP,
     3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAW,NVENR,NSTUO,JON,
     4LAST,TCFV,T8FV,I8UG,ICARD,PRISM,KP,IOHY,KVOL,EF
C
      A=0.0
      EF=0.0
      DO 5 N=1,11
    5 PCUV8(N)=0.0
      OO 10 N=1,10
   10 P8FV8(N)=0.0
      OO 15 N=1,5
   15 P8FV16(N)=0.0
C
C ASSUME BRKNG POINT OF 19.0 INCH O8H FOR BLACKJACK ANO OLO GROWTH TREES
C TOT TREE VOL EOUATIONS FROM MYERS,C.A.,USFS RES. PAPER RM-2,1963.
C CONVERT HALF-LOG HT(ITRHT) TO LOG HT(16FT SECTIONS)
C
      HT16=FLOAT(ITRHT)/2.
      OSOR=O8H**2
      IF(PRISM) 13,13,14
   13 OIV=OSQR*0.005454
      EF=8AFV/OIV
      GO TO 16
C
   14 EF=PRISM
   16 A=OSQR*HT16
      IF(O8H-19.0) 17,1R,1R
   17 IF(A.GT.8DO.) TCFV=0.044204*A + 8.266
      IF(A.GT.800.) T8FV=0.300D81*A - 52.090112
      IF(A.LE.8DO.) TCFV=D.046*A + 6.8
      IF(A.LE.800.) T8FV=0.224793*A + 8.1656
      GO TO 19
   18 IF(A.GT.100D.) TCFV=0.045736*A + 10.857212
      IF(A.GT.1130.) T8FV=0.326427*A - 62.962331
      IF(A.LE.1000.) TCFV=D.D50666*A + 5.R668
      IF(A.LE.1130.) T8FV=D.275784*A - 5.09125
C
C CU8IC FT VDL 8Y HALF-LOG THIS TREE + TOP
C
   19 KTOP=ITRHT + 1
      IF(ITRHT-1)2D,20,25
   20 ISKP=1
      GO TO 35
   25 ISKP=0
      OO 30 N=2,ITRHT
   3D ISKP=ISKP + N
      ISKP=ISKP + 1
   35 OO 40 N=I,KTOP
      PCUV8(N)=(TCFV*KCUV8(ISKP))/10D.
      ISKP=ISKP + 1
   40 CDNTINUE
C
C 8OARD FT VOL 8Y HALF-LOG THIS TREE
C
      KTOP=ITRHT - 1
      IF(ITRHT-1)45,45,5D
   45 ISKP=I
      GO TO 6D
   50 ISKP=0
      OO 55 N=1,KTOP
   55 ISKP=ISKP + N
      ISKP=ISKP + 1
   60 OO 65 N=1,ITRHT
      PRFV8(N)=(T8FV*K8FV8(ISKP))/100.
      ISKP=ISKP + 1
   65 CONTINUE
C
C 8OARD FT VOL 8Y SAW LOG(16FT) THIS TREE
C
      LP=HT16 - 0.5
      IF(HT16-1.)10D,7D,75
   7D LS=1
      GO TO 9D
   75 N=HT16
      X=N
      D=HT16 - X
      IF(0)80,80,85
   80 LS=N**2
      GO TD 90
   85 LS=N**2 + N
   90 KTDP=LP + 1
      OO 95 N=1,KTOP
      P8FV16(N)=(T8FV*K8FV16(LS))/100.
      LS=LS + 1
   95 CONTINUE
  100 RETURN
      ENO

      FUNCTION CVOL (V8L,PRISH,EF)
C-----
C-----ROUTINE TO CONVERT VOLUHE TO VOLUHE/ACRE FDR PLOTLESS CRUISING
C-----AND TO CONVERT VOLUME OF FIXEO SIZEO PLOTS ACCOROING TD A CONSTANT
C-----
      IF(PRISH.NE.0.0) CVOL=V8L*PRISM
      IF(PRISH.NE.0.0) GO TO 5
      CVOL=VBL*EF
    5 RETURN
      END

      SU8ROUTINE STOER (NSAM,Y,S,AHTRX,POINT)
C-----CALCULATES STANOARD ERROR OF THE MEAN FOR CLUSTER SAMPLING WITH
C-----UNEQUAL NUMBER OF SU8PLOTS PER CLUSTER
      OIHENSION AHTRX(1), POINT(1)
C-----NSAM=NUMBER OF SAMPLE CLUSTERS(INPUT)
C-----Y=OUTPUT MEAN
C-----S=OUTPUT STANOARO ERROR OF THE MEAN
C-----AMTRX=INPUT OATA VECTOR OF SIZE NSAM
C-----POINT=NUMBER OF SAMPLE POINTS FOR NSAM CLUSTERS
      P=FLOAT(NSAM)
      Y=0.0
      G=0.D
      OO 1 NC=1,NSAM
      IF (POINT(NC).EQ.0.0) GO TO 1
      OIV=AMTRX(NC)/POINT(NC)
      Y=Y+OIV*OIV
      G=G+OIV
    1 CONTINUE
      XB=(Y-(G*G)/P)/(P-1.)
      S=SORT(XB/P)
      Y=G/P
      RETURN
      ENO
```

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

POLES CONSIDERED AS SINGLE PRODUCT

DIAMETER CLASS	POLES PER ACRE BY HEIGHT CLASS 10	15	20	25	30	35	40	45	50	55	60	65	70	75
12	0.00	0.00	0.00	.58	.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	.52	.47	.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEIGHT CLASS SUM	0.00	0.00	0.00	1.09	1.08	.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STD ERR MEAN	0.00	0.00	0.00	.55	1.08	.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

SAWLOGS CONSIDERED AS SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

DIAMETER CLASS		BOARD FOOT VOLUMES PER ACRE BY GRADE 1	2	3	5
12	MEAN	0.00	0.00	0.00	292.60
	STD ERR	0.00	0.00	0.00	40.11
14	MEAN	0.00	0.00	0.00	300.44
	STD ERR	0.00	0.00	0.00	73.05
16	MEAN	0.00	0.00	0.00	53.38
	STD ERR	0.00	0.00	0.00	53.38
18	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
20	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
22	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
24	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
26	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
28	MEAN	0.00	0.00	0.00	80.42
	STD ERR	0.00	0.00	0.00	80.42
30	MEAN	0.00	0.00	60.08	102.95
	STD ERR	0.00	0.00	60.08	93.11
32	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
34	MEAN	0.00	0.00	49.58	63.10
	STD ERR	0.00	0.00	49.58	63.10
TOTAL MEAN		0.00	0.00	109.66	892.89
STD ERR MEAN		0.00	0.00	109.66	67.47

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

PULP CONSIDERED AS SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

TOTAL PULP VOLUME IN CUBIC FEET 234.43

STANDARD ERROR 13.63

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

VENEER CONSIDERED AS A SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

DIAMETER CLASS		BOARD FOOT VOLUMES PER ACRE BY GRADE 1	2	3	4
12	MEAN	0.00	74.11	73.61	0.00
	STD ERR	0.00	37.07	18.20	0.00
14	MEAN	0.00	94.52	121.03	0.00
	STD ERR	0.00	31.46	58.31	0.00
16	MEAN	0.00	0.00	42.70	0.00
	STD ERR	0.00	0.00	42.70	0.00
18	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
20	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
22	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
24	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
26	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
28	MEAN	0.00	43.43	14.48	0.00
	STD ERR	0.00	43.43	14.48	0.00
30	MEAN	0.00	103.00	0.00	12.02
	STD ERR	0.00	54.40	0.00	12.02
32	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
34	MEAN	0.00	65.36	0.00	0.00
	STD ERR	0.00	65.36	0.00	0.00
TOTAL MEAN		0.00	380.42	251.82	12.02
STD ERR MEAN		0.00	165.55	113.56	12.02

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

STUDS CONSIDERED AS SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

DIAMETER CLASS		BOARD FOOT VOLUMES PER ACRE BY GRADE 1	2	3	4
12	MEAN	42.06	115.54	32.93	93.98
	STD ERR	42.06	63.70	32.93	8.76
14	MEAN	9.78	76.67	17.85	159.55
	STD ERR	9.78	45.17	17.85	75.95
16	MEAN	0.00	0.00	0.00	42.70
	STD ERR	0.00	0.00	0.00	42.70
18	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
20	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
22	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
TOTAL MEAN		51.83	192.21	50.78	296.23
STD ERR MEAN		38.12	108.25	50.78	111.14

Heidt, Jack D., Donald A. Jameson, Roland L. Barger, and Bernard J. Erickson.
1971. Determining timber conversion alternatives through computer analysis. USDA Forest Serv. Res. Pap. RM-74, 27 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

The computer program MULTI accepts basic field inventory data describing individual sample trees. It calculates gross board-foot and cubic-foot volume, grades or classifies for a number of specified primary products, adjusts gross volume for visual defect, and calculates standard error. Output tables indicate adjusted gross volume per acre, by grade and size class, for each product independently. An option allows allocation of volume between several products of a multiproduct combination following a specified order of preference.

MULTI was developed on a CDC 6400 computer system. It is written in FORTRAN Extended Language, and can use tape and/or disk storage. Although the program was developed for products and grading systems common to ponderosa pine (*Pinus ponderosa* Laws.), it is adaptable to other species, products, and grading systems.

Key Words: Multiproduct timber inventory, primary product evaluation (timber), forest surveys, product volume estimates, product volume adjustments, timber utilization.

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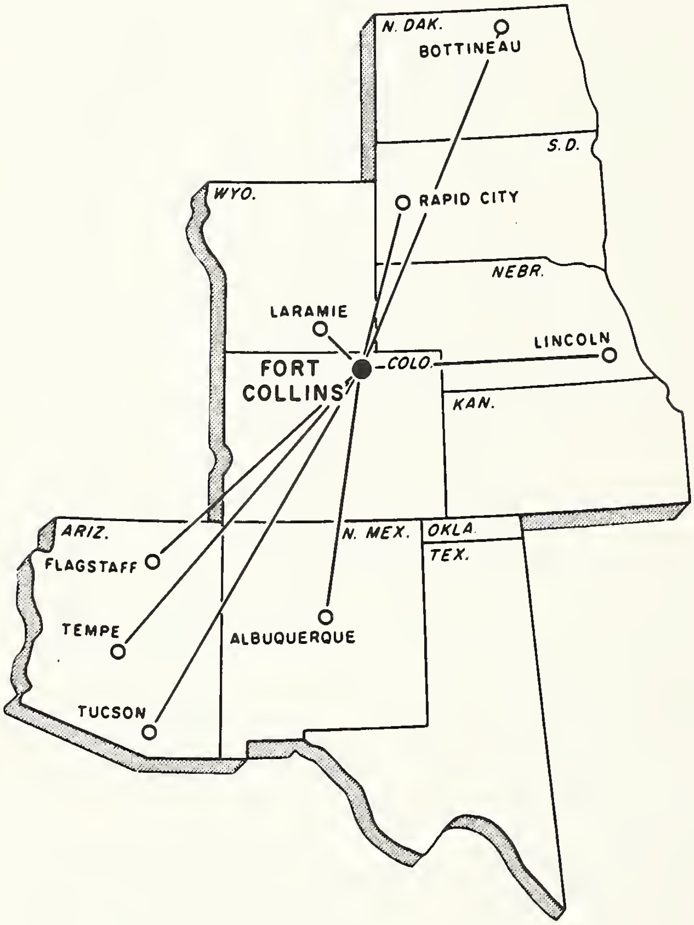
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